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ABS

Business Supplement

ANNUAL MEETING

The Annual Meeting of the Academy of Sciences was held in the Vizianagram Hall, Muir College Buildings, Allahabad, at 4 p. m. on Saturday, January 20, 1934. The Hon'ble Sir Shah Sulaiman, Kt., M.A., LL.D., Chief Justice, High Court, Allahabad, presided over the function. Prof. A. C. Banerji, the General Secretary, read the Annual Report of the Academy of Sciences for 1933.

Dr. K. N. Bahl, D. Sc., D. Phil., the President of the Academy, read his address. The Hon'ble Sir Shah Sulaiman then delivered his speech.

Prof. N. R. Dhar proposed a vote of thanks to the Hon'ble Sir Shah Sulaiman and Dr. H. R. Mehra seconded the vote of thanks.

SECRETARIES' REPORT

We have the honour to submit the following report on the working of the Academy during the period beginning from the 1st of January, 1933, and ending on the 31st of December, 1933.

The Second Annual meeting of the Academy of Sciences was held in the Vizianagram Hall, Muir College Buildings, Allahabad, on Friday, January 13, 1933. The Hon'ble Mr. J. P. Srivastava, the Minister of Education, presided over the function. His Excellency Sir William Malcolm Hailey, the PATRON of the Academy, whose keen interest and affection for the Academy are well-known, sent an inspiring message of hope and encouragement to the members of the Academy.

The Academy is making steady progress and has acquired a definite status in the eyes of the Scientists in India and abroad. It has now on its roll 117 members of whom 27 are non-resident members. Dr. S. S. Bhatnagar of Lahore was elected a Fellow of the Academy. We are much indebted to Government for the non-recurring grant of Rs. 2,000 which we received during the current financial year.

We are glad to mention that the Bulletin of the Academy has attained a high level of achievements and has been well received in the scientific world.

We are now receiving in exchange 99 Foreign an[illegible] ...m-pared to 53 Journals last year. 'NATURE', the well-know[illegible] journal of Great Britain, remarks in its issue dated 23rd of September, 1933, "The original memoirs published in the issues of the Academy represent a high standard of achievements." As the number of original papers submitted to the Academy is steadily increasing, it has become necessary to increase the size of the Bulletin and if possible to publish six issues of the same in each year instead of four as at present. Moreover the necessity of publishing a popular scientific journal is keenly felt. We shall have also to organise a scientific library for the province. But we are unable to give effect to our ideas and extend the sphere of our useful activities with the present non-recurring grant of Rs. 2,000 per annum. We hope and trust that Government will place us under further obligation by sanctioning a recurring grant of Rs. 4,000 per annum.

We are also indebted to the University of Allahabad for a grant of Rs. 500 during the current year, and shall approach also the other Universities of these Provinces for suitable grants. The need for a building of the Academy is urgently felt, and an appeal for raising money for this purpose will soon be issued. We shall require a Lecture Hall, a Reading Room, a Library and an Office in this building.

The thanks of the Academy are due to the Hon'ble Minister of Education, U. P., for founding a Gold Medal to be awarded to the author of the best paper published in the Bulletin in any year. The rules for the award of the medal have been framed.

The Academy welcomed the proposal of its Council that the name of the Academy of Sciences, U. P., be changed to the Indian Academy of Sciences. Dr. M. N. Saha, as the General President of the Indian Science Congress, 1934, was asked to bring the above resolution to the notice of the Scientists, who assembled at Bombay, and to discuss the whole question with them.

The General Committee of the Indian Science Congress at Bombay decided in favour of founding an Indian Academy of Sciences, and a committee has been formed to frame the constitution of the above Academy, and to take necessary steps for bringing into existence. The Academy of Sciences, U. P., has been invited to send a representative to serve in this committee.

The Academy conveyed its respectful felicitations to His Excellency Sir William Malcolm Hailey, the Patron of the Academy, on the conferment of the degree of Doctor of Laws by the University of Allahabad, for his eminent services to the cause of scientific research and education.

Our thanks are due to Mr. Narendranath Ghatak, M.Sc., for kindly helping us in the publication of the Bulletin. We also wish to express our thanks to the other office-bearers and the members of the Council of the Academy for their ungrudging help and active co-operation.

ABSTRACTS OF THE PROCEEDINGS

The list of the Office-Bearers and Members of the Council to which the management of the affairs of the Academy was entrusted for the year 1933-34 is given in appendix A.

Appendix B contains the list of names of 117 members who were on the roll of the Academy on March 31st, 1934.

The Council expressed its deep gratitude to the Government for the non-recurring grant of Rs. 2,000 awarded to the Academy for the year 1933-34.

It was resolved that provided the Government of the United Provinces have no objection, the name, "The Academy of Sciences of the United Provinces of Agra and Oudh" be changed to "The Indian Academy of Sciences."

The Council expressed its gratefulness to the Hon'ble Minister of Education, U. P., for founding a Gold Medal to be awarded to the author of the best paper published in the Bulletin in any year, and framed the following rules for its award:—

1. The medal will be awarded annually, provided in the opinion of the Council there is a candidate whose work is of sufficient merit.

2. The medal will be awarded in a particular year in one of the five groups of subjects mentioned below.

The group of subjects will be taken in rotation, provided that if no award is made in any particular year, the Council may award the medal for the group of the year in any subsequent year.

The following are the five groups of subjects :—

(i) Zoology and Medicine. anthropology
(ii) Mathematics and Astronomy.
(iii) Physics and Engineering.
(iv) Chemistry and Technology.
(v) Botany, Agriculture and Geology.

3. A person to whom a medal has been awarded once shall not be eligible for it a second time.

4. The medal shall be awarded on the basis of the merit of the paper published in the Bulletin or Journal of the U. P. Academy of Sciences, or in any other publication of the Academy.

5. The Council of the Academy shall ordinarily appoint three judges who must be experts in the subject to consider the award of the year.

Each judge shall submit his report separately and without consulting the other judges to the Council in a sealed cover marked "Confidential."

The President of the Council or in his absence the Vice-President or a Secretary shall open the covers in the presence of the members of the Council. The Council shall, after considering the reports of the judges, decide

upon the relative merits of the candidates for the medal and resolve upon the person to whom the medal should be awarded. If in the opinion of the Council no candidate deserves the award of the medal, it may withhold the award of the same.

While considering the reports of the Judges, the Council may, if it so desires, take into consideration at its own initiative any other work published by the Academy even the author of such a work has not submitted it for the award of the medal.

6. The Secretary will invite the authors to submit their papers for the medal by the end of July each year. The Council shall appoint the judges in August and the Secretary will submit the papers to them by the middle of September. The judges shall submit their reports by the end of October, and the Council shall decide the award at its Annual Meeting in November. The medal will be presented to the successful competitor in the Anniversary Meeting, and a statement of the grounds on which the award has been made will be made by the President.

7. A member of the Council so long as he remains a member, will not be eligible for the medal.

8. Only Members and Associates will be eligible for the medal.

9. No award shall be made merely on the basis of joint paper, but joint paper may be taken into consideration by the judges in considering the award.

10. In any matter not provided for here considering the award of the medal, the decision of the Council shall be final.

The following one member was elected Fellow of the Academy in the Fellow's meeting held on November 8, 1933:

1. Dr. S. S. Bhatnagar, D.Sc., Professor of Chemistry, Government College, Lahore.

The following members were elected Office-Bearers and the Members of the Council for the year 1934 in the Annual Meeting held on January 20, 1934:

President :

1. Prof. K. N. Bahl, D. Sc., D.Phil.

Vice-Presidents :

2. Prof. M. N. Saha, D.Sc., F.R.S., F.A.S.B., F.Inst. P., P.R.S.
3. Prof. B. Sahni, D.Sc., Sc. D., F.L.S., F.A.S.B.

Honorary Treasurer :

4. Prof. D. R. Bhattacharya, M.Sc., Ph.D., D.Sc., F.Z.S.

General Secretaries:

5. Prof. P. S. MacMahon, B.Sc., M.Sc., F.I.C.
6. Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S.

Foreign Secretary:

7. Prof. N. R. Dhar, D.Sc., F.I.C., I.E.S.

Other Members of the Council:

8. Prof. Nihal Karan Sethi, D.Sc.
9. Dr. S. S. Nehru, M.A., Ph.D., I.C.S., M.L.C.
10. Prof. C. A. King, B.Sc., A.R.C. Sc., M.I.M.E.
11. Prof. Ch. Wali Mohammad, M.A., Ph.D , I.E.S.
12. Dr. H. R. Mehra, Ph.D.
13. Prof. Rudolf Samuel, Ph.D.
14. Dr. S. M. Sane, B.Sc., Ph.D.
15. Prof. C. Maya Das, B.Sc., M.A., I.A.S.
16. Prof. K. C. Pandya, D.Sc.

APPENDIX A

LIST OF OFFICE-BEARERS AND MEMBERS OF THE COUNCIL 1933

President :

1. Prof. K. N. Bahl, D.Sc , D. Phil.

Vice-Presidents :

2. Prof. M. N. Saha, D.Sc., F.R.S , F.A.S.B., F. Inst. P., P.R.S.
3. Prof. B. Sahni, D.Sc., Sc.D., F.L S., F.A.S.B.

Hony. Treasurer :

4. Prof. D. R. Bhattacharya, M.Sc., Ph.D., D.Sc., F.Z.S.

General Secretaries :

5. Prof P. S. MacMahon, B.Sc., M.Sc., F.I.C.
6. Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S.

Foreign Secretary :

7. Prof. N. R. Dhar, D.Sc., F.I.C., I.E.S.

Other Members of the Council :

8. Prof. K. C. Mehta, Ph.D., M.Sc.
9. Dr. S. S. Nehru, M.A., Ph.D., I.C.S., M.L.C.
10. Prof. Ch. Wali-Mohammad, M.A., Ph.D., I.E S.
11. Prof. K. K. Mathur, B.Sc., A.R.S.M.
12. Dr. P.L. Srivastava, M.A.; D. Phil.
13. Prof. Robert F. Hunter, D.Sc., Ph.D.
14. Dr. S. M. Sane, B.Sc., Ph.D.
15. Prof. C. Maya Das, B.Sc., M.A., I.A.S.
16. Prof. K. C. Pandya, D.Sc.

APPENDIX B

ORDINARY MEMBERS

R—Resident. N—Non-Resident.

*—Denotes a Fellow.

Alphabetical List of Ordinary Members

Date of Election		
17-4-1931	R	Asundi, (R.K.), Ph.D., Reader, Physics Department, Muslim University, Aligarh.
21-12-1931	N	Bagchi, (S.C.), B.A., LL.D., Principal, Law College, Calcutta
1-1-1930	R*	Bahl, (K.N.), D. Phil., D.Sc., Professor of Zoology, Lucknow University, Lucknow
1-1-1930	R*	Banerji, (A.C.), M.A., M.Sc., F.R.A.S., I.E.S., Professor of Mathematics, Allahabad University, Allahabad.
29-2-1932	R	Banerji, (G.N.), The Scientific Instrument Company Ltd., Albert Road, Allahabad.
22-12-1932	N	Banerji, (S.K.), D.Sc., Meteorological Office, Ganeshkhind Road, Poona 5.
17-4-1931	N	Basu, Saradindu, M.Sc., Meteorologist, Ganeshkhind Road, Poona 5.
19-3-1931	R	Bhargava, Saligram, M.Sc., Reader, Physics Department, Allahabad University, Allahabad.
17-4-1931	R	Bhargava, Vashishta, M.Sc., I.C.S., Assistant Magistrate and Collector, Budaun.
17-4-1931	R	Bhatia, (K.B.), I.C.S., Joint Magistrate, Shahjahanpur.
21-4-1933	N*	Bhatnagar, (S.S.), D.Sc., Professor of Chemistry, Government College, Lahore.
1-1-1931	R*	Bhattacharya, (D.R.), M.Sc., Ph.D., Docteur ès Sciences, Professor of Zoology, Allahabad University, Allahabad.
17-4-1931	R	Bhattacharya, (D.P.), M.Sc., Bareilly College, Bareilly.
3-4-1933	R	Chand, Tara, M.A., D. Phil., Principal, K. P. University College, Allahabad.
29-2-1932	R	Charan, Shyama, M.A., M.Sc., Agra College, Agra.
1-1-1930	R*	Chatterji, (G.), M.Sc., Meteorologist, Upper Air Observatory, Agra.
17-4-1931	R	Chatterji, (K.P.), M.Sc., A.I.C., F.C.S., Reader, Chemistry Department, Allahabad University, Allahabad.
17-4-1931	R	Chatterji, (A.C.), D.Sc., Chemistry Department, Lucknow University, Lucknow.

Date of Election.		Alphabetical List of Ordinary Members
9-2-1934	R	Chaturvedi, Champa Ram, Pandit, Professor of Mathematics, St. John's College, Agra.
19-3-1931	R	Chaudhury, Rabindra Nath, M.Sc., M.A., Mathematics Department, Allahabad University, Allahabad.
17-1-1931	R	Chaudhury, (H.P.), M.Sc., Lucknow University, Lucknow.
19-3-1931	R	Das, Ramsaran, D.Sc., Zoology Department, Allahabad University, Allahabad.
17-4-1931	R	Das, C. Maya, M.A., B.Sc., I.A.S., Principal, Agricultural College, Cawnpore
28-10-1932	N	Das, (A.K.), D.Sc., Alipore Observatory, Alipore, Calcutta.
22-12-1932	N	Das, (B.K.), D.Sc., Professor of Zoology, Osmania University, Hyderabad, Deccan.
15-9-1931	R	Dasannacharya, (B.), Ph.D., Professor of Physics, Benares Hindu University, Benares.
17-4-1931	R	Deodhar, (D.B.), Ph.D., Reader, Physics Department, Lucknow University, Lucknow.
17-4-1931	R	Dey, (P.K.), M. Sc., I.A.S., Plant Pathologist to Government, United Provinces, Nawabganj, Cawnpore.
29-2-1932	R	Deb, Suresh Chandra, D.Sc., Physics Department, Allahabad University, Allahabad.
1-1-1930	R*	Dhar, (N.R.), D.Sc., Docteur ès Sciences, F.I.C., Professor of Chemistry, Allahabad University, Allahabad.
1-1-1930	R*	Drane, (H.D.H.), M.Sc., Ph.D., A.M.I.E.E., A.M.I. Chem. E., Principal, Harcourt Butler Technological Institute, Cawnpore.
19-3-1931	R	Dutt, (S.K), M.Sc., Zoology Department, Allahabad University, Allahabad.
17-4-1931	R	Dutt, (S.B.), D.Sc., Reader, Chemistry Department, Allahabad University, Allahabad.
28-10-1932	R	Dutt, (A.K.), D.Sc., Benares Hindu University, Benares.
17-4-1931	R	Forman, (D.N.), M.D., Jumna Dispensary, Allahabad.
22-2-1933	R	Ghatak, Narendranath, M.Sc., Chemistry Department, Allahabad University, Allahabad.
19-4-1931	R	Ghosh, (B.N.), M. Sc., St. Andrew's College, Gorakhpur.
8-11-1933	N	Ghosh, (J.C.), D.Sc., The University, Dacca.
19-3-1931	R	Ghosh, (R.N.), D.Sc., Physics Department, Allahabad University, Allahabad.
19-3-1931	R	Ghosh, Satyeshwar, D.Sc., Chemistry Department, Allahabad University, Allahabad.
15-9-1931	N	Gogate, (D.V.), M.A., Baroda College, Baroda.

Date of Election		Alphabetical List of Ordinary Members
15-9-1931	R	Gordon, (C.B.), B.A., Christ Church College, Cawnpore.
17-4-1931	R	Gupta, (B.M.), D.Sc., Deputy Public Analyst to Government, United Provinces, Lucknow.
21-12-1931	R	Hansen, (W.J.), M.A., Allahabad Agricultural Institute, Naini, E.I.R., Allahabad.
17-4-1931	R	Higginbottom, Sam, D. Phil., Principal, Allahabad Agricultural Institute, Naini, E.I.R., Allahabad.
17-4-1931	R*	Hunter, Robert (F.), D.Sc., Ph.D., Professor of Chemistry, Muslim University, Aligarh.
21-12-1931	R	Joshi, (S.S.), D.Sc., Professor of Chemistry, Benares Hindu University, Benares.
15-9-1931	N	Kichlu, (P.K.), D.Sc., Department of Physics, Government College, Lahore.
1-1-1930	R*	King, (C.A.), B.Sc. (Hons.), A.R.C.Sc., M.I.M.E., Principal, Engineering College, Benares Hindu University, Benares.
21-4-1933	N	Kishen, Jai, M.Sc., Professor of Physics, S.D. College, Lahore.
17-4-1931	R	Koshambi. (D.D.), M.A., Department of Mathematics, Muslim University, Aligarh.
9-2-1934	N	Kothari, (D.S.), M.Sc., Ph.D., Professor of Physics, The University, Delhi.
5-10-1933	R	Kureishy, (A.M.), M.A., Reader in Mathematics, Muslim University, Aligarh.
1-1-1930	R*	Luxmi Narayan, D.Sc., Reader, Mathematics Deparment, Lucknow University, Lucknow.
1-1-1930	R*	MacMahon, (P.S.), B.Sc. (Hons.), M.Sc., Professor of Chemistry, Lucknow University, Lucknow.
1-1-1930	R*	Mathur, (K.K.), B.Sc. (Hons.), A.R.S.M., Professor of Geology, Benares Hindu University, Benares.
1-1-1930	R*	Mehta, (K.C.), Ph.D., M.Sc., Agra College, Agra.
1-1-1930	R*	Mitter, (J.H.), M.Sc., Ph.D., Professor of Botany, Allahabad University, Allahabad.
15-9-1931	R	Mathur, (L.P.), M.Sc., St. John's College, Agra.
8-11-1933	N	Mathur, Ram Behari, M.Sc., Professor of Mathematics, St. Stephen's College, Delhi.
19-3-1931	R	Mazumdar, Kanakendu, D.Sc., Physics Department, Allahabad University, Allahabad.
19-3-1931	R*	Mehra, (H.R.), Ph.D., Reader, Zoology Department, Allahabad University, Allahabad.
21-12-1931	R	Mehta, (N.C), I.C.S., Director of Agriculture, United Provinces, Lucknow.

Date of Election.		Alphabetical List of Ordinary Members
21-4-1933	N	Mela Ram, M.Sc., Asst. Professor of Physics, Foreman Christian College, Lahore.
21-4-1933	R	Mukerjee, (A.C.), M.A., Philosophy Department, Allahabad University, Allahabad.
21-4-1933	N	Mukerjee, Ashutosh, M.A., Professor of Physics, Science College, P. O. Bankipore (Patna.)
17-4-1931	R	Mukerjee, (S.K.), M.Sc., Agra College, Agra.
17-4-1931	R	Mukerjee, (S.K.), D.Sc., Reader, Botany Department, Lucknow University, Lucknow.
19-12-1933	R	Naithani, (S.P.), M.Sc., Botany Department, Allahabad University, Allahabad.
22-2-1933	R	Narliker, (V. V.), M.A., Professor of Mathematics, Benares Hindu University, Benares.
17-4-1931	R	Nehru, (S. S.), M.A., Ph.D., I.C.S., M.L.C., Deputy Secretary to Government, U.P., Publicity Department, Lucknow.
17-4-1931	R	Panday, (K.C.), D.Sc., St. John's College, Agra.
3-4-1933	N	Parija, (P. K.), M.A., I.E.S., Ravenshaw College, Cuttack.
5-10-1933	R	Prasad, Gorakh, D.Sc., Reader in Mathematics, Allahabad University, Allahabad.
21-4-1933	N	Prasad, Kamta, M.A., M.Sc., Professor of Physics, Science College, P.O. Bankipore (Patna).
15-9-1931	N	Prasad, Mata, D.Sc., Royal Institute of Science, Bombay.
3-4-1933	R	Prasad, Badrinath, Ph.D., Docteur ès Sciences, Mathematics Department, Allahabad University, Allahabad.
17-4-1931	R	Puri, (B.D), M. A., Thomason Civil Engineering College, Roorkee.
22-12-1932	N	Qureshi, (M.), M.Sc., Ph.D., Professor of Chemistry, Osmania University College, Hyderabad, Deccan.
3-4-1933	R	Raja Ram, M.A., B.E., Principal of Civil Engineering, Thomason College, Roorkee, U.P.
19-3-1931	R	Ranjan, Shri, M.Sc., Docteur ès Sciences, Reader, Botany Department, Allahabad University, Allahabad.
15-9-1931	N	Rao, A. Subba, D.Sc., Medical College, Mysore.
22-2-1933	N	Rao, G. Gopala, B.A., M.Sc., Chemistry Department, Andhra University, Waltair.
21-12-1931	R	Rao, D. H. Ramchandra, B.E., A.M.I.E., Engineer, Allahabad University, Allahabad.
22-2-1933	N	Ray, Bidhubhusan, D.Sc., 92 Upper Circular Road, Calcutta.
21-12-1931	R	Ray, Satyendra Nath, M.Sc., Physics Department, Lucknow University, Lucknow.

Date of Election		Alphabetical List of Ordinary Members
1-1-1930	R*	Richards, (P.B.), A.R.C.S., F.E.S.. Entomologist to the Government, United Provinces, Cawnpore.
1-1-1930	R*	Saha, (M. N.), D.Sc., F.R.S., F.A.S.B., F. Inst. P., P.R.S., Professor of Physics, Allahabad University, Allahabad.
29-2-1932	R	Saha, Jogendra Mohan, M.Sc., Manager, Srikrishna Desi Sugar Works, Jhusi, (Allahabad).
1-1-1930	R*	Sahni, (B.), D.Sc., Sc.D., F.L.S., F.A.S.B., Professor of Botany, Lucknow University, Lucknow.
17-4-1931	R*	Samuel, Rudolf, Ph.D., Professor of Physics, Muslim University, Aligarh.
17-4-1931	R	Sane, (S.M.), B.Sc., Ph.D., Reader, Chemistry Department, Lucknow University, Badshah Bagh, Lucknow.
21-12-1931	R	Sathe, (J.L.), I.C.S., Finance Secretary to Government, U. P., No. 1, Secretariat Quarters, Lucknow
3-4-1933	R	Sen, (K. C.), D.Sc., Imperial Institute of Veterinary Research, Muktesar, Kumaun.
21-4-1933	N	Seth (J.B.), M.A., Government College, Lahore.
17-4-1931	R	Seth, (S.D.), M.Sc., Christ Church College, Cawnpore.
1-1-1930	R*	Sethi, (R.L.), M.Sc., M.R.A.S., Economic Botanist to Government, United Provinces, Cawnpore.
19-3-1931	R	Sethi, Nihal Karan, D.Sc., Agra College, Agra.
15-9-1931	R	Sharma, Ram Kishore, M.Sc., Physics Department, Ewing Christian College, Allahabad.
3-4-1933	N	Siddiqi, (M.R.), Ph D. Professor of Mathematics, Osmania University, Hyderabad, Deccan.
3-4-1933	R	Siddiqui, Mohd. Abdul Hamid, M. B. B. S., M. S., F. R. C. S., D. L. O., Professor of Anatomy, King George's Medical College, Lucknow.
17-4-1931	R	Singh, Avadesh Narain, D.Sc., Department of Mathematics, Lucknow University, Lucknow.
17-4-1931	N	Soonawala, (M.F.), M.Sc., Maharaja's College, Jaipur (Rajputana).
19-3-1931	R*	Srivastava, (P.L.), M.A., D.Phil., Reader, Mathematics Department, Allahabad University, Allahabad.
10-8-1933	R	Srivastava, (R. C.), B.Sc., (Tech.) Sugar Technologist, Imperial Council of Agricultural Research, India, Cawnpore.
15-9-1931	N	Srikantia, (C.), B.A., D.Sc., Medical College, Mysore.
19-12-1933	R	Strang, (J.A.), M.A., B.Sc., Professor of Mathematics, Lucknow University, Badshah Bagh, Lucknow.

Date of Election		Alphabetical List of Ordinary Members
24-1-1933	N	Subramanian, (S.), M.A., Mathematics Department, Annamalai University, Annamalainagar P. O., South India.
17-4-1931	R	Sulaiman, (S.M.), Hon'ble Sir, Chief Justice, High Court, Allahabad.
19-3-1931	R	Taimini, Iqbal Kishen, Ph.D., Chemistry Department, Allahabad University, Allahabad.
19-3-1931	R	Tewari, Shri Govind, M.A., Mathematics Department, Allahabad University, Allahabad.
3-4-1933	R	Thompson, (C. D.), M.A., Professor of Economics, Allahabad University.
19-3-1931	R	Toshniwal, (G.R.), M.Sc., Physics Department, Allahabad University, Allahabad.
9-2-1934	R	Vaugh, Mason, B.Sc.·Ing., Agricultural Engineer, Allahabad Agricultural Institute, Naini, E.I.Ry. (Allahabad).
19-3-1931	N*	Vijayaraghavan, (T.), D.Phil., Reader, Mathematics Department, Dacca University, Ramna, Dacca.
1-1-1930	R*	Wali Muhammad, Ch., M.A., Ph.D., I.E.S, Professor of Physics, Lucknow University, Lucknow.
15-9-1931	R	Wall, (W. G. P.), M.Sc., I.E S., Associate I.E.E., M.R.S.T., Inspector of Schools, Allahabad Division, Allahabad

N.B.—The Secretaries will be highly obliged if the members will kindly bring to their notice errors, if there be any, in their titles, degrees, and addresses.

LIST OF MEMBERS OF THE PUBLICATION COMMITTEES 1933.

Mathematics

1. Prof. A C. Banerji, M.A, M.Sc., F.R.A.S., I.E.S, Professor of Mathematics, Allahabad University, Allahabad.

Physics

2. Prof. M. N. Saha, D.Sc., F.R.S., Professor of Physics, Allahabad University, Allahabad.
3. Prof. Ch. Wali Mohammad, M.A., Ph.D., I.E.S., Professor of Physics, Lucknow University, Lucknow.

Chemistry

4. Prof. N. R. Dhar, D.Sc., I.E.S., Professor of Chemistry, Allahabad University, Allahabad.
5. Prof. P. S. MacMahon, B.Sc., M.Sc., Professor of Chemistry, Lucknow University, Lucknow.

Zoology

6. Prof. D. R. Bhattacharya, D.Sc., Ph.D., Professor of Zoology, Allahabad University, Allahabad.
7. Prof. K. N. Bahl, D.Phil., D.Sc., Professor of Zoology, Lucknow University, Lucknow.

Botany

8. Prof. B. Sahni, D.Sc., Sc.D., F.L.S., F.A.S.B., Professor of Botany, Lucknow University, Lucknow.
9. Prof. K. C. Mehta, Ph.D., M.Sc., Professor of Botany, Agra College, Agra.

Mining and Geology

10. Prof. K. K. Mathur, B.Sc., A.R.S.M., Professor of Geology, Benares Hindu University, Benares.

Agriculture

11. Prof. C. Maya Das, M.A., B.Sc., I.A.S., Principal, Agricultural College, Cawnpore.
12. Dr. Sam Higginbottom, Principal, Agricultural Institute, Naini, E.I.R. (Allahabad).

LIST OF EXCHANGE JOURNALS

	Journals	Publishers
1.	The Bell System Technical Journal ...	The American Telephone and Telegraph Coy., New York (U. S. A.)
2.	Proceedings of the Imperial Academy of Japan.	The Imperial Academy, Ueno Park, Tokyo.
3.	Journal of the Franklin Institute ...	The Franklin Institute of the State of Pennsylvania, Philadelphia, Penna, (U. S. A.)
4.	Bell Telephone System (Technical Publications).	The Bell Laboratories, New York.
5.	Collected Researches of the National Physical Laboratory.	The National Physical Laboratory, Teddington, Middlesex, England.
6.	Report of the National Physical Laboratory.	Ditto.
7.	The Electrician	The Electrician, Bouverie House, London.
8.	Proceedings of the Cambridge Philosophical Society.	The Philosophical Society, Cambridge.
9.	Proceedings of the Royal Society of Edinburgh.	The Royal Society of Edinburgh, Edinburgh, England.
10.	Journal and Proceedings of the Asiatic Society of Bengal.	The Asiatic Society of Bengal, Calcutta.
11.	Proceedings of the Indian Association for the Cultivation of Science.	The Indian Association for Cultivation of Science, Calcutta.
12.	Scientific Notes of the India Meteorological Department.	The Director-General of Observatories, Poona 5.
13.	Memoirs of the India Meteorological Department.	Ditto
14.	Bulletin of the Madras Government Museum, Natural History Section.	The Connemara Public Library, Egmore.
15.	Bulletin of the Patna Science College Philosophical Society.	The Patna Science College Philosophical Society, Patna.
16.	Journal of the Indian Institute of Science	The Indian Institute of Science, Bangalore.
17.	Transactions of the Bose Research Institute.	The Bose Research Institute, Calcutta.
18.	Current Science	The Indian Institute of Science, Bangalore.
19.	Transactions of the Royal Society of Canada.	The Royal Society of Canada, Ottawa.
20.	Fifty Years Retrospect, Anniversary Volume.	Ditto
21.	Journal of the Royal Astronomical Society of Canada.	The Royal Astronomical Society of Canada, Toronto, Canada.

Journals	Publishers
22. Publications of the Dominion Astrophysical Observatory.	The Dominion Astrophysical Observatory, Victoria, Canada.
23. Dominion of Canada Natural Research Council.	Ditto.
24. Proceedings of the Royal Society of Victoria.	The Royal Society of Victoria, Melbourne, Australia.
25. Journal and Proceedings of the Royal Society of New South Wales.	The Royal Society of New South Wales, Sydney, Australia.
26. Transactions and Proceedings of the New Zealand Institute.	The New Zealand Institute, Wellington, New Zealand.
27. Publications of the Alleghany Observatory.	The Alleghany Observatory of the University of Pittsburgh, Alleghany City (U.S.A.)
28. Publications of the Observatory of the University of Michigan.	The Observatory Library, University of Michigan, Michigan (U. S. A.)
29. Lick Observatory Bulletin	The Lick Observatory, University of California, Berkeley (U. S. A.)
30. Proceedings of the American Academy of Arts and Sciences.	The American Academy of Arts and Sciences, Boston (U. S. A.)
31. Memoirs of the American Academy of Arts and Sciences.	Ditto.
32. Journal of Mathematics and Physics ...	The Massachusetts Institute of Technology, Cambridge, Mass. (U. S. A.)
33. Proceedings of the National Academy of Sciences.	The National Academy of Sciences, Washington (U. S. A.)
34. Proceedings of the Academy of Natural Sciences of Philadelphia.	The Academy of Natural Sciences, Philadelphia (U. S. A.)
35. Year Book	Ditto.
36. Astrophysical Journal	The Astrophysical Journal, University of Chicago, Chicago. Illinois (U. S. A.)
37. Proceedings of the American Philosophical Society.	The American Philosophical Society, Philadelphia (U. S. A.)
38. American Journal of Science ...	The American Journal of Science, New Haven (U. S. A.)
39. Bureau of Standards, Journal of Research.	The Director, Deptt. of Commerce, Bureau of Standards, Washington (U. S. A.)
40. Contributions from the Mount Wilson Observatory.	The Mount Wilson Observatory, Pasadena, California (U. S. A.)
41. Communications (Solar Observatory)	Ditto.
42. Annual Report of the Director of the Mount Wilson Observatory.	Ditto.
43. Journal of Chemical Physics ...	The American Institute of Physics, New York, N. Y.
44. Review of Scientific Instruments ...	Ditto.

	Journals	Publishers
45.	Transactions of the Astronomical Observatory of Yale University.	The Astronomical Observatory of Yale University, New Haven (U. S. A.)
46.	Publication in Zoology ...	... The University Library, Exchange Deptt., Berkeley, California (U. S. A.)
47.	The Philippine Journal of Science ...	The Library, Bureau of Science, Manila P. I. (U. S. A.)
48.	Anzeiger (Mathematics and Science) ...	Akademie der Wissenschaften, Vienna, Austria.
49.	Almanack	Ditto.
50.	Anzeiger (Philosophy and History) ...	Ditto.
51.	Bulletin de La Classe Des Sciences ...	The Academie Royale de Belgique, Brüssels, Belgium.
52.	Annales De L'Institute Henri Poincare.	The Institut Henri Poincare, Paris (France).
53.	Mathematische Und Naturwissenschaftliche Berichte Ana Ungaru.	The Ungarische Akademie der Wissenschaft, Buda-Pest, Hungary.
54.	Sitzungsberichte Der Preussischen Akademie.	Preussischen Akademie der Wissenschaften, Berlin, Germany.
55.	Berichte Der Deutschen Chemischen Gesellschaft.	Deutsche Chemische Gesellschaft, Berlin, Germany.
56.	Nachrichten Von der Gesellschaft der Wissenschaften Zu Gottingen. Mathematisch-Physikalische Klasse.	Gesellschaft der Wissenschaften, Zu Göttingen, Germany.
57.	Geschaftliche Mitteilungen ...	Ditto.
58.	Mathematische Naturwissenschaftliche Klasse.	Bibliothekar, Heidelberger Akademie der Wissenschaften, Heidelberg, Germany.
59.	Berichte Der Mathematische Physischen Klasse.	Sachsische Akademie der Wissenschaften, Leipzig. C. I.
60.	Abhandlungen Der Mathematisch-Physischen Klasse.	Ditto.
61.	Sitzungsberichte der Mathematisch-Naturwissenschaftlichen.	Bayerische Akademie der Wissenschaften Zu Munchen, München, Germany.
62.	Communications from the Physical Laboratory, Leiden.	The Physical Laboratory, Leiden, Holland.
63.	Supplement, Communications from the Kamerlingh Onnes Laboratory.	Ditto.
64.	Rendiconti-Del Circolo Mathematico Di Palermo.	Palermo (Italy).
65.	National Research Council of Japan. ...	The National Research Council of Japan, Tokyo, Japan.
66.	Japanese Journal of Mathematics ...	Ditto.
67.	Japanese Journal of Botany ...	Ditto.
68.	Japanese Journal of Physics ...	Ditto.
69.	Science Report of the Tohoku Imperial University.	The Director of the Library, Imperial University of Tohoku, Sendai, Japan.

	Journals	Publishers
70.	Proceedings of the Physico-Mathematical Society of Japan.	The Physico-Mathematical Society of Japan, Tokyo, Japan.
71.	Scientific Papers of the Institute of Physical and Chemical Research.	Komagome, Hongo, Tokyo.
72.	Journal of Science of the Hiroshima University (Zoology).	The Hiroshima University, Hiroshima, Japan.
73.	The Keijo Journal of Medicine ...	The Medical Faculty, Keijo Imperial University, Chosen, Japan.
74.	Bulletin De L'Academie Des Sciences Mathematiques at Naturelles.	The Akademie der Wissenschaft, Leningrad, Soviet-Russia.
75.	Jouranl Du Cycle De Physique et De Chemie.	Academie des Sciences D'Ukraine, Kyiv, Ukraine.
76.	Journal Du Cycle Mathematique ...	Ditto.
77.	Bulletin de La Classe des Sciences Physiques et Mathematiques.	Ditto.
78.	Memorias Do Instituto Oswaldo Cruz.	The Instituto Oswaldo Cruz, Brazil (U.S.A.)
79.	Physikalische Zeitschrift Der Sowjetunion.	Physical Journal of the Soviet Union, Kharkov, Chikovsakaya 16, Soviet-Russia.
80.	Geographical and Biological Studies of Anopheles Maculipennis in Sweden.	Kungliga Svenska Vetenskapsakademie, Stockholm, Sweden.
81.	Kungl. Fysiografiska Sällskapets Forhandlingar.	The Universitet, Lund, Sweden.
82.	Uppsala Universitets Arsskrift ...	Universitet, Uppsala, Sweden.
83.	Compte Rendu Des Seances De La Societe De Physique et D'Histoire Naturelle.	Societe D'Histoire Naturelle et de Physique, Geneva, Switzerland.
84.	Comptes Rendus Mensuels Des Seances De La Classe De Medecine.	Academie Polonaise Des Sciences et Des Lettres, Cracovie.
85.	Comptes Rendus Mensuels Des Seances De La Classe Sciences Mathematiques et Naturelles.	Ditto.
86.	Bulletin International De L'Academie Polonaise Des Sciences et Des Lettres Classe Des Sciences Mathematiques et Naturelles. Serie A.	Imprimerie De L'Universite, Cracovie.
87.	Ditto Ditto Serie B. 1.	Ditto.
88.	Ditto Ditto Serie B. 2.	Ditto.
89.	Bulletin International De L'Academie Polonaise Des Sciences et Des Lettres Classe De Medecine.	Ditto.
90.	Sprawozdania Z posiedzen Towarzystwa Naukowego Warszawskiego (History Literatury).	Societe des Sciences et des Lettres de Varsovie, Warsaw, Poland.

	Journals	Publishers
91.	Sprawozdania Z posiedzen Towarzystwa Naukowego Warszawskiego (Phisiology).	Societe des Sciences et des Lettres de Varsovie, Warsaw, Poland.
92.	Ditto (Matematycznofizycznych)	Ditto.
93.	Ditto (Biologicznych) ...	Ditto.
94.	Bureau of Fisheries (Document) ...	The Commissioner of Fisheries, Washington (U.S.A.)
95.	Science Bulletin	University of Kansas, Lawrence, Kansas (U.S.A.)
96.	Mathematisk-Fysiske Meddelelser ...	Kongelige Danske Videnskabernes Selskab, Copenhagen, Denmark.
97.	Biologiske Meddelelser.	Ditto.
98.	Transactions of the Royal Society of South Africa.	The Royal Society of South Africa, University of Cape-Town, Rondebosch, South Africa.
99.	Comptes-Rendus des Travaux Du Laboratoire Carlsberg.	The Carlsberg Laboratorium, Kobenhavn, Valby, Denmark.

JOURNAL SUBSCRIBED BY THE ACADEMY OF SCIENCES, U.P., DURING THE YEAR 1933.

PHYSICS

1.	Die Naturwissenschaften, 21 Jahrgang.	Hirschwaldsche Buchhandlung, Berlin, N.W.7.

LIST OF PAPERS READ BEFORE THE ACADEMY OF SCIENCES, U. P., DURING THE PERIOD APRIL, 1933, TO MARCH, 1934.

1. "Colour and Chemical Constitution. Auxochromic Effect of Hydroxyl and Amino Groups on Phthalophenone Nucleus," by Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
2. "Chemical Examination of the Roots of *Theretia Neriifolia* (Juss)," by Narendranath Ghatak, M.Sc., and G. P. Pendae, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
3. "On the Trematode Parasites of a Rangoon Siluroid Fish-Clarias Batrachus (Linnaeus 1785)," by R. C. Chatterjee, M.Sc., Helminthological Institute, University of Rangoon, Rangoon.
4. "On the Absorption Spectra of the Oxides of Zinc and Cadmium," by P. K. Sen Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
5. "The Absorption Spectra of the Vapours of the Lower Chlorides of Elements of the Fifth Group of Periodic Table," by Hrishikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.
6. "A Note on the Vapour Pressure of Zinc Bromide," by M. S. Desai, M.Sc., Physics Deptt., Allahabad University, Allahabad.
7. "On the Absorption Spectra of Sulphides of Zinc and Mercury," by P. K. Sen Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
8. "On the Absorption Spectrum of Lead Monoxide and Lead Monosulphide," by R. S. Sharma, M.Sc., Physics Deptt., Allahabad University, Allahabad.
9. "On the Absorption Spectra of Hydrogen Peroxide," by R. S. Sharma, M.Sc., Physics Deptt., Allahabad University, Allahabad.
10. "On the Determination of the Values of γ for Air Saturated with Water Vapour at Various Temperatures," by Haji Gulam Mohammad, M.Sc., Physics, Deptt., Allahabad University, Allahabad.
11. "A Contribution to the Morphology of *Digera Arvensis*," by S. P. Naithani, M.Sc., Botany Deptt., Allahabad University, Allahabad.
12. "On New Trematodes of Frogs and Fishes of the United Provinces, India."
    Part I. New Distomes of the Family Hemiuridæ Luhe 1901 from North Indian Fishes and Frogs with a systemic discussion on the family Halipegidæ Poche 1925 and the Genera Vitellotrema Guberlet 1928 and Genarchopsis Ozaki 1925," by Har Dayal Srivastava, M.Sc., Zoology Department, Allahabad University, Allahabad.
13. "On the Absorption Spectra of Some Higher Sulphides," by P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
14. "On the Absorption Spectra of Some Saturated Halides," by R. S. Sharma, M.Sc., Physics Deptt., Allahabad University, Allahabad.
15. "On New Trematodes of Frogs and Fishes of the United Provinces, India."
    Part II. On Three New Trematodes of the Sub-family Pleurogenetinæ (family Lecithodendriidæ) from Rana Cyanophlyctis of Oudh, by Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

16. " Effect of Direction of Speaking and of Pitch in the Assam Council Chamber," by B. C. Ghosh, Prof. of Physics, Vidyasagar College, Calcutta, and Satyendranath Ray, M.Sc., Lecturer, Physics Deptt., Lucknow University, Lucknow.
17. " On the Trematodes of Frogs and Fishes of the United Provinces, India."

    Part III. On a New Genus Mehraorchis and two New Species of Pheurogenes (Pleurogenetinæ) with a systematic discussion and revision of the family Lecithodendridæ, by Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

18. "On a New Trematode with Anus belonging to the Genus Opegaster Ozaki 1928, from an Indian Eel Auguilla Bengaleusis," by K. R. Harshey, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
19. "On the Synonymy of Caphalogonimus Magnus Sinha with Cephalogoniums Gangeticus Pande and the account of a New Species of the Genus," by B. P. Pande, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
20. " Chemical Examination of the Seeds of *Abrus precatorius*, Linn."

    Part II. The colouring matter of the Seed-coat, by Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.

21. "A Note on the Optical Activity of the Alkaloidal Salts of Violuric Acid," by Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
22. " On Synge's Paper", by S. Subramanian, Lecturer in Mathematics, Annamala University, Annamalainagar P. O., South India.
23. "Absorption Spectra of Coloured Organic Salts of Violantin and Alloxantin" by Kedar Nath Gaind and Sikhibhusan Dutt, Chemistry Deptt., Allahabad University, Allahabad.
24. "Chemical Examination of the Leaves of the *Nyctanthes Arbortristis* Linn," by Jagraj Behari Lal and Sikhibhusan Dutt, Chemistry Deptt., Allahabad University, Allahabad.
25. "The Problem of the Stellar Structure, Part I," by D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.
26. " On the Absorption Spectra of the Halides of Elements of the Fifth Group," by Hrihsikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.
27. " On the Horizontal Comparison for the Location of Spectra of Heavy Elements," by S. C. Deb, M.Sc., Physics Deptt., Allahabad University, Allahabad.
28. "Cytoplasmic Inclusions in the Oogenisis of Passer Domesticus," by Murli Dhar Lal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
29. "Chemical Examination of the Bark of *Nerium Odorum*," by G. P. Pendse, M.Sc., and Sikhibhusan Dutt, Chemistry Deptt., Allahabad University, Allahabad.
30. "On the Absolute Summability (A) of Fourier Series," by M. L. Misra, Mathematics Department, Agra College, Agra.
31. " On the β-ray Activity of Radioactive Bodies," by M. N. Saha, F.R.S., and D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.
32. "Is the Neutron or the Proton the Fundamental Particle" ? by D. S. Kothari, Ph.D., Physics Deptt, Allahabad University, Allahabad.

33. "New Blood Flukes of the Family Spirorchisae Stunkard from Indian Fresh-Water Tortoises with Discussions on the Synonymy of Certain Genera and the Relationships of the Families of Blood-Flukes, Part II," by Dr. H. R. Mehra, Ph.D., Zoology Deptt., Allahabad University, Allahabad.

34. "Studies in the Viscosity Variations due to Chemical Reactions in Liquid Media," Part I, by Shridhar Sarvottam Joshi and Susarla Raju, Benares Hindu University, Benares.

35. "A Theorem Concerning the Zeros of the Laplace-Abel Integral," by Mr. S. P. Jain, M.Sc., Mathematics Deptt, Allahabad University, Allahabad.

36. "On the Absorption Spectrum of Nitrogen Monoxide in the Schumann Region," by Mr. P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.

37. "On an Interpretation of Absorption Spectra of Molecules," by Mr. P. K. Sen-Gupta, M.Sc., Allahabad University, Physics Deptt., Allahabad.

38. "On Amphistome Parasites of Sheep and Goat from Allahabad," by Mr. K R. Harshey, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

39. "On New Trematodes of Frogs and Fishes of the United Provinces, India."

Part IV. Occurence and the Seasonal Incidence of Infection of Certain Trematodes in the Above Hosts, by Mr. Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

40. "Neutrons and Stellar Models," by Dr. D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.

41. "On Experiments in Acoustic Correction of the U. P. Legislative Council Chamber, Lucknow," by Mr. Satyendra Ray, M.Sc., Physics Deptt., Lucknow University, Lucknow.

42. "On the Absorption Spectra of Some Simple Salts of the Transition Elements. Contribution to the Theory of the Co-ordinative Linkage V[1], by Messrs. R. Samuel and S. Mujtaba Karim, Physics Deptt., Muslim University, Aligarh.

43. "Chemical Examination of the Seeds of *Abrus Precatorious*, Linn."

Part III. The Constitution of Abrine, by Mr. Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.

44. "Synthesis of Substituted Cinchoninic Acids through the Knœvwnagel Catalysts," by Mr. Madhusudanan Pandala, Chemistry Deptt., Andhra University, Waltair.

45. "The Application of Franck-Condon Principle to Continuous Absorption Spectra of Diatomic Molecules," by Mr. Hrishikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.

46. "On a Formula for $\pi_v(\chi)$, by Mr. S. M. Shah, M.A., Mathematics Deptt., Muslim University, Aligarh.

47. "A New View about the Bacteriophage and the Filtrable Viruses," by Mr. Ramesh S. M. Prabhu, M.Sc., Chemistry Deptt., Benares Hindu University, Benares.

48. "The Effects of Different Fresh Fruit Juice Media on Certain Strains of Helminthosporium," by Mr. Pestonji R. Bhagwagar, M.Sc., Botany Deptt., Allahabad University, Allahabad.

49. "The Quantum Analogue of a Theorem of Poison in Classical Dynamics," by Dr. D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.

50. "The Origin of Combined Nitrogen in the Atmosphere. The Analysis of Tropical Rain and its Importance in Agriculture," by Mr. Atma Ram, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.

51. "Notes on Bessel Functions," by Dr. S. C. Mitra, Ph.D , Mathematics Department, Dacca University, Dacca.

52. "On the Absorption Spectra of the Oxides of the Alkaline Earth Metals," by Mr. P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.

53. "Cytoplasmic Inclusions in the Oogenesis of Muska Domestica," by Mr. Murli Dhar Lal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

54. "On the Summability of Fourier Series by Arithmetic Means," by Dr. B. N. Prasad, M. Sc., Ph. D., D.Sc., Mathematics Deptt, Allahabad University, Allahabad.

55. "Chemical Examination of the Seeds of *Plantago ovata* (Esabghol), by Messrs. G. P. Pendse and S. Dutt, Chemistry Deptt., Allahabad University, Allahabad.

56. "On a New Trematode from an Indian Fresh-water Fish," by Mr. B. P. Pande, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

57. "Nuclear Structure, γ-Ray Fission, and Expanding Universe," by Prof. A. C. Banerji, I.E.S., M.A., M.Sc., Professor of Mathematics, Allahabad University, Allahabad.

58. "Chemical Examination of Punar-Nava or *Boerhaavia Diffusa*," by Messrs. Radha Raman and S. Dutt., Chemistry Deptt, Allahabad University, Allahabad.

59. "On Two New Trematodes of the Genus Opegaster Ozaki with a Systamatic Discussion on the Families Opecoelidae Ozaki 1925 and Coitocaecidæ Ozaki 1928," by Mr. K. R. Harshey, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

60. "On the Theory of the Absorption of Poly Atomic Molecules," by Mr. M. S. Desai, M.Sc., Physics Deptt., Allahabad University, Allahabad.

61. "On the Linkage of Certain Oxides," by Drs. H. Lessheim and R. Samuel, Physics Deptt., Muslim University, Aligarh.

62. "On Changes on the Circular Orbit of a Particle when Disturbed by Small Tangential and Normal Impulse," by Mr. Avadh Behari Lal, M.Sc., Ramjas College, Delhi.

63. "Effect of Temperature on Borax Solutions in the Presence of Polyhydric Substances and Organic Acids," by Mr. S. M. Mehta, Royal Institute of Science, Bombay.

64. On a New Distome Ascocotyle Intermidius from the Indian Fishing Eagle, with remarks on the Genera Ascocotyle looss 1899 and Phagicola Faust 1920, (Family– Heterophyidæ). by Mr. Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

65. "Fluorescent Radiation from N_2O," by Mr. P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.

66. "The Electronic States of Tin monochloride molecule and its Electron quantum numbers," by Mr. Hrishikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.

Financial Statement—From 1st January, 1933, to 31st March, 1934

Receipts

	Rs.	a.	p.	Rs.	a.	p.
Opening balance on 1st Jaunary, 1933 ...				8	12	3
Bank balance on 1st January, 1933 ...				2,425	0	6
Government Grant (Non-recurring) ...				2,000	0	0
Allahabad University Grant for 1933-34 (Non-recurring) ...				500	0	0
Membership Fee:—						
Resident membership fee for 1931	60	0	0			
Resident membership fee for 1932	165	0	0			
Non-resident membership fee for 1932 ...	10	0	0			
Resident membership fee for 1933	540	0	0			
Non-resident membership fee for 1933	180	0	0			
Resident membership fee for 1934	135	0	0			
Non-resident membership fee for 1934	50	0	0			
Partpayment of subscription for 1935	5	0	0	1,145	0	0
Discount on outstation cheques of membership subscriptions				1	0	0
Total Rs. ...				6,079	12	9

Expenditure

	Rs.	a.	p.
Establishment	835	0	0
Contingency (Including printing, postage stamps, and stationery, etc.) ...	544	1	6
Journals for 1933 and 1934	110	15	6
Printing of Bulletin Vol. 2, Nos. 2, 3, and 4, 1932-33	1,402	9	6
Printing of Bulletin Vol. 3, Nos. 1 and 2, 1933	705	3	6
Binding of journals	184	8	0
Furniture	42	0	0
Bank Charges on outstation cheques ..	5	12	0
Bank Balance:—			
Building Fund 66 0 0			
**Balance in hand Rs. 2,183 10 9	2,249	10	9
Total Rs. ..	6,079	12	9

	Rs.	as.	p.	Rs.	as.	p.
**Details of Balance in hand	2,183	10	9			
Establishment				5	0	0
Contingency				94	1	6
Journals				89	0	6
Printing of Bulletin 1932-33				226	9	6
Printing of Bulletin 1933-34				994	12	6
Binding of journals				12	0	0
Furniture				58	0	0
Building Fund				66	0	0
Balance in hand to meet expenses till the receipt of the next Government grant ...				704	2	9
				2,249	10	9

D. R. Bhattacharya, D.Sc., Ph. D., F. Z. S.,
Hony. Treasurer,
The Academy of Sciences of the United
Provinces of Agra and Oudh.

Message from His Excellency Sir W. Malcolm Hailey, The Patron of the Academy

This meeting of the Academy of Sciences receives additional importance from the proposal for an all-India Academy which was mooted at the recent Science Congress held at Bombay. The share taken by some of the members of the U. P. Academy of Sciences in that Congress shows the importance which the Academy has attained in the scientific world of India; every one will, I am sure, hope that it will receive increasing support and achieve continued success.

(Sd.) W. M. Hailey,
Governor,
United Provinces.

January 5, 1934.

Message from The Hon'ble Mr. J. P. Srivastava, The Minister of Education, U. P.

Thank you so much for your letter of the 3rd. I am so sorry it will not be possible for me to be present at the third annual meeting of the Academy of Sciences which will be held at Allahabad on Saturday, January 20, 1934, as I have another engagement for that day. I am, however, watching the progress of your Academy with great satisfaction. I am sure it will in time become the premier academy of its kind in India. From all accounts the Science Congress at Bombay has been a great success and I am proud of the part which the U. P. scientists played in it.

With kind regards,

Yours sincerely,
(Sd.) J. P. Srivastava,
Minister of Education,
United Provinces.

January 8, 1934.

PRESIDENT'S ADDRESS

ADDRESS OF THE PRESIDENT, PROFESSOR K. N. BAHL, AT THE ANNIVERSARY MEETING HELD ON JANUARY 20, 1934.

THE HON'BLE THE CHIEF JUSTICE, FELLOWS AND MEMBERS OF THE ACADEMY, LADIES AND GENTLEMEN,—My very first duty as President of the Academy is to accord on its behalf a hearty welcome to the Hon'ble Sir Shah Mohammad Sulaiman, Kt., M.A., LL D., the Chief Justice of the Allahabad High Court, who has kindly come over to preside at our anniversary meeting this afternoon. Although his main work lies in the administration of Law and Justice, he is known to take a keen interest in science. He has been a member of our Academy since its inception and I understand that he employs his spare time these days in the study of higher physics and in researches on theory of the universe, a subject on which he has promised to give us his own views this afternoon. We all hope that his association with us will help us in furthering the cause of scientific research in these provinces.

We are assembled to-day to celebrate so to speak, the third birthday of our Academy, which now enters the fourth year of its existence. In this country, almost notorious for its heavy infant-mortality, it is a matter for congratulation that the Academy, under the fostering care of Dr. M. N. Saha, its founder and first President and Professors Banerji and MacMahon, its energetic and painstaking secretaries,. has not only survived its period of infancy but is showing signs of developing into a healthy and promising child.

The honorary secretaries have placed before you an account of the progress made by the Academy during the year and I am sure, you will all agree, that with our limited resources, we have achieved a great measure of success. We wish to expand our activities in several directions but we lack the means for such expansion. And I have no doubt that as our work receives the appreciation it deserves, the Government and public at large will give us the financial support that we need.

I have selected "The Present Position of Darwinism" as the subject of my address, as the doctrine of Evolution forms one of the two most important generalizations of Biology and is also of application in other branches of human knowledge.

Present Position of Darwinism

The year 1858 forms a landmark in the history of scientific progress, nay even that of human thought, since it was in that year that Darwin and Wallace

formulated the great principle that Organic Evolution had occurred chiefly as a result of the action of *Natural Selection.* That evolution had taken place was known long before; Darwin even Darwin's grandfather Erasmus Darwin believed in the fact of evolution—in fact, some people have even traced the idea of evolution in the writings of ancient Greeks like Lucretius and Empedocles, but the great achievement of Charles Darwin was to give a satisfactory explanation, supported by copious evidence, of the *factors* which had brought about evolution. We must, therefore, at the very outset distinguish between the *fact* of evolution and the *theories* of evolution, for we must remember that "Darwin did not discover Evolution, as many people suppose, but he gave an account of the operating causes for the process of evolution."[1] That evolution has taken place is a fact supported by incontrovertible evidence and forms not only the accepted creed of all scientific men but has even permeated the thought and vocabulary of historians and political philosophers and even of theologians. But *how* evolution has taken place is the crucial question and Charles Darwin's great contribution was the answer to this question. Seventy-five years have elapsed since the publication of Darwin's classic, the "Origin of Species" and I shall attempt during the short time at my disposal to discuss how far the Darwinian hypothesis of Natural Selection has stood the test of critical biological thought.

Professor Huxley, who was a most ardent champion of Darwin's theory and called himself "Darwin's bull-dog," summarises the Darwinian hypothesis in these words:—

"All *species* have been produced by the development of varieties from common stocks: by the conversion of these, first into *permanent races* and then into *new species*, by the process of *natural selection*, which process is essentially identical with that of artificial selection by which man has originated the races of domestic animals—the *struggle for existence* taking the place of man and exerting, in the rase of natural selection, that selective action which he performs in artificial selection."[2]

Darwin observed that variations occurred in nature; he postulated that these would be inherited from generation to generation and that in the multitude of individuals produced by every living species, all competing against each other for food and a place under the sun there will be a *struggle for existence* and consequently the *survival of the fittest.* The chief factors contributing to the process of evolution, according to Darwin, were variation, heredity and the struggle for existence leading to Natural Selection.

Let us begin our discussion by considering the nature, origin and inheritance of variations. Unfortunately our knowledge of this part of the

[1] Wells, Huxley and Wells—*The Science of Life,* 1931.
[2] Huxley's Collected Essays—Vol. II, p. 71.

subject was extremely limited in Darwin's time but the great impetus given by the Darwinian theory has resulted in a rich harvest of observed facts and experimental deductions, which have led to a correction and re-statement of this part of Darwin's theory. We are all familiar with the fact that parents and offspring, brothers and sisters are never quite alike; they always differ from each other and we call these differences *variations.* This variability occurs in every kind of character, shape, size and colour in simple cases of plants and animals, while in man "the most complex capacities, such as fertility, the power of resistance to disease, and intellectual ability are notoriously variable."[1] We can think of the enormous possibilities of variation, if we bear in mind the fact that variation may occur at any or all stages of life in the egg, the embryo, the young or the adult of an animal and of a plant.

But in spite of these variations, which are sometimes very striking, we have the great principle of heredity working all the time and it is this great conserving force that accounts for the countless resemblances in the whole organisation of one generation and the next. When the characters of a parent re-appear in the offspring, in popular language we say that the characters are inherited. In sexual reproduction, the male contributes the sperm and the female the egg and these two together go to make up the offspring. The offspring is, therefore, really a growth of the detached bits of its parents;[1] "it is a chip of the old block", in fact of two blocks since there are two parents The great German zoologist Weismann put forward the idea that as it is part of a man and a woman which grows into their children—it is really their own living substance which is handed on from generation to generation and he used the term *germ-plasm* for this immortal bit of the organism to distinguish it from the *soma* or the remainder of the body which is mortal. The *soma* lives and dies but the germ-plasm goes on indefinitely. If life had a single origin, all the living organisms would be traced to one stock—they would all be the twigs of the original tree or trunk of the germ-plasm. This conception of Weismann is called the theory of the *continuity of germ-plasm.* We can thus think of an actual material continuity between our own germ-plasm and that of the original living organism that first appeared on the surface of this earth.

The question naturally arises as to how it is that with this continuity of germ-plasm, we have the wonderful variety and diversity of form that we find amongst organisms. We must have variation in the germ-plasm in order to have any variation amongst organisms at all. The older naturalists assumed that the use and disuse of organs and the external environment generally induced changes in the organisms and that these changes were

[1] Goodrich—*Living Organisms*, 1924.

transmitted and reappeared in the progeny. This point of view was specifically put forward long before Darwin by the French naturalist Lamarck who gave as example the case of the long neck of the giraffe; according to him the ancestral giraffe stretched its neck to reach the leaves of the higher branches of trees, the offspring kept up this useful habit which was inherited, so that by generations of continuous stretching of the neck, the species has acquired this permanent character of a long neck. Lamarck would seem to say, "Master what you can of Mathematics and your child will calculate with greater ease."[1] Darwin himself was hard put to explain the origin of variations and for want of an adequate explanation, he accepted that variations were the effects of differences in environment but he was not quite comfortable about the matter since he wrote to Huxley, "If, as I must think, external conditions produce little effect, what the devil determines each particular variation."[2] Unfortunately Lamarck's theory of the inheritance of acquired characters has not been able to stand the test of critical examination and has been largely overthrown. Weismann tested it experimentally by cutting off the tails of mice, generation after generation, but the young mice continued to grow tails. Similarly the effects of use and disuse, *e.g.*, the enlargement of muscles in the arm of a blacksmith or even the results of education have not been proved to be inherited as such from one generation to the next. The fact is, as Weismann postulated, that the change induced in the *soma* or body cannot be transmitted to the offspring; for any hereditary change, the *germ-plasm* must be modified. These conclusions of Weismann form a most important contribution to the science of evolution since the time of Darwin.

Another valuable point of view first advocated by Professor Sedgwick and developed later by Sir Archdall Reid and other is that each character of an organism is the product both of factors of inheritance in the germ-plasm and of environment and can only be reproduced when both are present. Not only every part of an organism but all its habits and activities are the results of the combined action of factors of inheritance and environment. We can distinguish between the effect of a factor of germ-plasm and that of the environment by a simple example. There is no more fundamental character of a green plant than its greenness. Yet if we grow the seed of the greenest plant in a dark chamber, the plant will not be green. The environmental stimulus of light is absent. We may say that "the green character is not transmitted, it is not inherited."[3] But what is really inherited is the capacity to become green and this capacity is present in the factors of the

[1] Wells, Huxley and Wells—*The Science of Life*, 1931.
[2] Haldane—*The Causes of Evolution*.
[3] Goodrich—*Living Organisms*, 1924.

germ-plasm, as can be seen at once by bringing the pale seedling into light, when it will turn green in a day or two. The presence of iron in the soil is another necessary condition for the development of green colour. The plant may have the necessary capacity and the brightest of sun-light, but lack of iron will not give the green colour. Similarly, the common belief that tuberculosis is transmitted from parent to offspring is fallacious. Tubercle bacilli are present almost everywhere in crowded streets and dirty surroundings but if your constitution is strong and your lungs healthy, you will not develop tuberculosis. What the offspring of a tuberculous patient will inherit will be a weak constitution and lungs susceptible to disease and if by adequate nourishment and other means, the constitution is made strong and the children are kept in clean and healthy surroundings, they need have no fear of getting tuberculosis at all. An organism, therefore, is the result of the interplay of the factors of inheritance and the conditions of the environment. In order to have a healthy plant, you need not only good seed but also a good well-manured soil.

From the point of view of variations, therefore, we must distinguish between variations produced by a germinal change in a constant environment and variations which are induced by a change in environment only while the germinal constitution continues the same. The former are called *mutations* and the latter *modifications*. These variations cannot be distinguished by a mere inspection but only by systematic observation and experiment. The analysis of variations by these means has been carried out only during the last 30 years and has yielded very interesting and useful results which constitute another notable advance in our knowledge of the process of evolution.

The impetus for this analysis of variations was provided by the re-discovery of Mendel's monumentel work in 1900. Working in the seclusion of the cloister garden at Brunn, this Austrian monk carried out experiments for eight years on the common pea plant and published his work in 1865, only six years after the publication of Darwin's "Origin of Species." For 35 years, his work was neglected but since 1900 it has become very famous. In simple terms, Mendelism postulates that it is the gametes, the egg and the sperm in the case of animals and the polien-grain and the ovule in the case of plants that carry the factors which are capable of giving rise to the characters of animal and plants. These factors are now called *genes*. Further, a given gamete can carry one and only one of any alternative pair of characters. In the pea plant, for example, it can carry either tallness or dwarfness but not both. In biological language, we describe this as Mendel's law of the *purity of the gametes*. If a tall pea plant has been crossed with a dwarf and the hybrids grow and flower, there will be a segregation of the characters tallness and dwarfness at the time of the formation of the gametes. With this simple principle added

to the law of dominance as a guide, biologists have built up a whole science of Heredity or Genetics and have succeeded wonderfully in extending the scope of Mendel's work and its applications. Through a knowledge of Mendel's law, biologists have been able to raise the desired breeds of animals and plants; they have been able to explain the mechanism of the determination of sex and the transmission of several diseases in man; in fact, Mendelism has provided the key to the working mechanism of heredity. We in India owe a deep debt of gratitude to Mendel whose discovery led Sir Rowland Biffen to raise a rust-proof variety of wheat at Cambridge and this in turn led the Howards at Pusa to raise the famous Pusa varieties of wheat which are gradually replacing the old indigenous varieties and which account for the increasing prosperity of the wheat-growing areas in the United Provinces and the Punjab. Similarly breeds of cow with a high rate of milk-yield have been raised and also breeds of poultry with a high rate of egg-production.

The thrilling problem of the determination of sex attracted a number of distinguished workers who have succeeded in elucidating the mechanism of sex-heredity. Doncaster and Raynor in England were the first to discover the phenomenon of sex-linked inheritance; Goldschmidt in Germany has worked out the mechanism of the so-called "intersexes," but the most outstanding contribution has been made by Morgan and his colleagues in America, who have carried the analysis a stage further by correlating sex-heredity with the differences in the chromosome constitution of the cells of the two sexes. In recognition of this work of his school, Thomas Hunt Morgan has only recently been awarded the Nobel Prize. A start was made by proving that sex is a definite, heritable character, exactly comparable to the tallness and dwarfness of the pea-plant or the black and blue colour of the eye in man. Cases of sex-linked inheritance were next worked out in moths and poultry, and finally in the fruit-fly *Drosophila*, the determination of sex was definitely proved to belong to one particular chromosome, the sex-chromosome. In man, two kinds of sperms—male-determining and female-determining—have been demonstrated, so that we now know exactly *how* sex is actually determined. Unfortunately we cannot yet *control* sex, although vigorous attempts are being made to discover a means of separating the male-producing from the female-producing sperms in order to paralyse one set or the other as desired. These attempts have not been successful thus far, but it may be not long before some one solves the problem and we may then have the means ready to decide the sex of our children and satisfy many people who are desperately anxious to have a child of a certain sex.

Several human defects and diseases have been shown to follow the line of simple Mendelian inheritance. Presenile cataract of the eye, night-blindness and colour blindness have been proved to follow Mendelin inheritance;

so does *haemophilia*, a disease which afflicted the late Tsar's ill-fated son and which brought the Tsarina, as the story goes, under the influence of Rasputin. Specially poignant to the Tsarina must have been the knowledge that this disease is transmitted by the mother herself to her sons alone. As our knowledge of heredity has increased, we have discovered out that certain diseases cannot be rooted out; they inevitably pass on from one generation to the next. Inherited feeble mindedness is one such disease and one can understand why Germany has made a law for compulsory sterilisation of the feeble minded and why there is a movement in England as well for a similar law although on a voluntary basis.

From the point of view of Darwinian Evolution, however, the chief contribution of Mendelism is to establish that heritable variation has a definite basis in the gamete and that it arises by a sudden step it is discontinuous, because it is based upon the presence or absence of some definite factor or factors in the gametes from which it sprang. Darwin's view was that a character was developed by the gradual accumulation of minute variations occurring at random and he emphasised this point by using a Latin phrase "*Natura nihil facit per saltum*" *i.e.*, Nature does not work by jumps. Bateson in 1895 pointed out that species do not pass gradually from one to the other but the differences between them are sharp and definite "Why don't we get intermediates of all sorts more frequently in nature?" he asked, "if specific differences arise by an accumulation of minute and almost imperceptible differences." De Vries, on a prolonged study of the evening primrose *Oenothera* concluded that new varieties arose from older ones by sudden sharp steps or "mutations." Finally all the work on Mendelian lines has convinced biologists that Darwin's idea of the summation or accumulation of minute random variations must be abandoned and that we must regard variations appearing as "sports" or mutations and their origin as due to the addition or subtraction of factors in the gametes. Once formed, natural selection decides whether these new characters will persist or not. It is these mutations, therefore, that furnish the raw materials of evolution. But the explanation is still incomplete. We have localised problem but have not succeeded in solving it yet. The origin of the new mutations has yet to be explained satisfactorily. Some biologists believe that in the course of the maturation of the germ-cells, which is a very important phase in their development, there is a re-shuffling of the cards in the pack of factors of hereditary characters; others attach great importance to fertilization or crossing and this is not surprising when we remember that two very complex systems, usually of diverse origin, become in the act of fertilization a unity that develops in most cases into a harmonious life. In fact, there is ample experimental evidence to show that novelties are induced by crossing but unfortunately

this factor alone does not seem sufficient to account for the origin of all new specific variations.

I now pass on to the essential part of the Darwinian hypothesis, *i.e.*, the action of *natural selection*, in respect of which Darwinism has emerged unscathed even from a most exacting scrutiny. In his "Origin of Species," Darwin emphasised in the first place the fact that living organisms multiply in geometrical progression and thus constantly tend to press upon their means of subsistence, this idea being probably due to Malthus. We know from observation that the daily life of animals and even of man is primarily a hunt for food; in fact, according to a French writer, life can be summed up in the conjugation of the verb "to eat"—its pleasant active voice (except for the dyspeptic) and its awful correlative, the passive[1]. In general, the total population of any region of the earth is a direct reflection of the balance between "I eat, you eat, he eats, etc." and the passive—"I am eaten, you are eaten and he is eaten, etc."[1]. Darwin took the example of the elephant as the slowest breeder amongst animals and estimated that if all the progeny of a single pair survived, in 500 years we shall have 15 million elephants. Yet the average number remains more or less steady, which means that only two young ones of a pair survive the rest die out. In this process it is the better equipped that survive and the worse-equipped die. The struggle for existence acts like a sieve; it selects those that possess advantageous variations and eliminates the useless and the undesirable.

That natural selection is at work all the time has now been proved experimentally, although such experimental evidence was lacking in Darwin's time. In 1904, di Cesnola tied up 20 green and 45 brown specimens of *Mantis* in green grass and found that after 19 days, 35 browns had been eaten by birds but none of the greens. Similarly when he tied brown and green *Mantises* on brown grass, the greens were all eaten while all the browns remained alive.[2] Here was natural selection at work through the agency of birds. Recently in 1920, Harrison has brought forward evidence to show natural selection at work among the moths of the species *Oporabia autumnata* in a mixed wood of pine and birch in Yorkshire, and several other workers have adduced similar evidence.

I shall not take your time in enlarging any further on this – the most important aspect of Darwinism, nor shall I deal, as I would very much like to, if I had the time with "isolation" as a maker of species, nor with the interesting question of Orthogenesis or straight-line evolution.

To sum up, we must conceive of a living organism as a complex of a large number of characters subject to mutations in succeeding generations.

[1] Dakin—*Introduction to Biology.*

[2] Haldance—*Causes of Evolution.*

These mutations are called forth by a change in the germ-plasm and are inherited. "But since many differences of an advantageous or disadvantageous sort exist and are inherited, the struggle for existence or natural selection acts on a species like a filter or a sieve. It selects types of success and failure, sets a premium on advantageous variations and continually removes a large majority of the disadvantageous ones, so that the average of the species moves in the advantageous direction."[1] Darwinism thus stands vindicated to-day; it has emerged almost unchanged after a most critical examination extending over three quarters of a century and serves to account for the process of Evolution with a cogency and a completeness unequalled by any other explanation.

1 Wells, Huxley and Wells—*The Science of Life*, 1931.

ADDRESS BY THE HON'BLE SIR SHAH MOHAMMAD SULAIMAN, Kt., M.A., LL.D., CHIEF JUSTICE, HIGH COURT, ALLAHABAD.

LADIES AND GENTLEMEN,

It is a great honour for me to preside at this assembly of learned scientists and I certainly feel that it is rather audacious on my part to attempt to discuss before you any scientific subject, in which I have not the time to specialise. But I can feel no hesitation in referring to the remarkable progress which the Academy of Sciences has made during the short period that it has been in existence.

As Prof. Banerji, the Hony. General Secretary, has shown in his Report for the last year, the number of members on the roll of the Academy has been steadily increasing. If this progress is maintained, as it is sure to be, the Academy will be a fully representative body of scientists engaged in scientific study or teaching work or in research.

The Bulletin issued by the Academy has contained valuable papers of a high order on various scientific subjects, which have been very much appreciated. The authors of the articles deserve to be congratulated on the valuable contributions made to the advancement of scientific knowledge. That the value of the Bulletin is fully recognised abroad is amply evidenced by the fact that it is already receiving in exchange about one hundred scientific Journals from almost all parts of the world. The Bulletin in this way is playing an important part and helping to build up a library of up-to-date scientific literature.

The success achieved so far has been due mainly to the inspiration and encouragement received from His Excellency Sir Malcolm Hailey, the Patron of the Academy, as well as to the enthusiasm and devotion of its Presidents, Secretaries and other office-bearers, who are sincerely endeavouring to raise it to the status of an All-India Academy of Sciences.

The branches of Science have now become so numerous and the accumulation of knowledge in each branch so vast, that even a whole-time scientist can never hope to master them. Much less can an amature like myself feel competent enough to deal with the engrossing problems of all the branches of the Science. I confess, I know very little about Biology. All of us have some perfunctory knowledge about evolution, but few of us know the details of thrilling problems like the determination of sex. But we are all indebted to Prof. Bahl for his very lucid and clear exposition of Darwinism. For the teeming millions who know nothing about birth control, it is certainly a happy news to be told that offsprings of tuberculous patients do not inherit the

disease. Physics is the only subject of which I have managed to keep up some knowledge in a very limited way. I have, therefore, to confine my address to one aspect of Modern Physics, which of all others is the most mysterious and an apparently unintelligible phenomenon. The present conception of light as the origin of all the modern troubles has led to the propounding of most amazing theories and apparently contradictory assumptions. The answers offered for some of the perplexing questions concerning the nature of light are designed to take us deep into the realm of unreality, where we not only lose all mental picture of it, but it becomes so illusory as to be entirely beyond our comprehension. Eminent scientists have to admit that the present theories have landed us in a *cul de sac* and there seems to be no way out of it without retracing our steps.

I have ventured to prepare my written address in the hope that a destructive criticism from an outside source, based upon a collection of the existing anomalies and contradictions, and if I may be permitted to say so, even absurdities in the modern ideas, may not only expose the utter inadequacy of the present day accepted views, but may perhaps pave the way for a new constructive theory, that will get over the existing difficulties.

As copies of my printed address are available to you all, I am relieved of the necessity of reading the whole of it. I shall accordingly content myself with reading only portions of it here and there.

THE ADDRESS

It is a great privilege to me to be invited to preside at this session of the Academy of Sciences. I have accepted the honour with considerable diffidence, because it is somewhat presumptuous on the part of any outsider to intrude upon the consecrated precincts of Science and be bold enough to make a critical survey of the development of any of its branches. One, who is absorbed in other engrossing pre-occupations and can hardly spare time for a devoted pursuit of scientific knowledge, much less its experimental side, would naturally hesitate to attempt to examine the very foundations upon which some of the modern conceptions of the structure of the Universe are based. But liberty of thought is not the sole monopoly of great scholars and eminent scientists only, and the portals of even a sacred cloister have, on occasions, been allowed to be invaded by an outside observer. I may, therefore, be excused for a somewhat similar encroachment.

In spite of the vast accumulations of the store of scientific literature, it must be admitted that human knowledge is still very much in its infancy. Our abysmal ignorance is at once revealed when we endeavour even to comprehend the vastness of the Nature around us. When we try to appreciate that the Sun, whose size is more than one million three hundred thousand times that of the Earth we inhabit, might well have existed for the last eight

million million years, that the Earth itself must have existed for the last two thousand million years and may yet last for a much longer period, that life on this Earth might well have existed for three hundred million years, while man could have hardly lived on it for more than three hundred thousand years, it becomes apparent that the period of a few thousand years during which the stock of human knowledge has been growing is but a negligible infinitesimal fraction of time, a mere drop in the fathomless ocean.

The great Sun is only a tiny speck in the vast Universe. Light travelling at the stupendous rate of 186,000 miles per second takes about eight minutes to come to the Earth from the Sun. But the light from even the nearest Stars takes not seconds, minutes, hours, days and months, but four years and a quarter, or more, to reach the Earth. There are some four hundred thousand million Stars, including our Sun, which form one Galactic system, bounded by the Milky Way, across which light at that terrific speed would take two hundred and twenty thousand years to travel from one end to the other. Outside this huge Galactic system there are still more distant nebulæ, some two millions of which are now visible in the great 100-inch telescope at Mt. Wilson. The most distant of these nebulæ revealed at present are so far away that light at the rate of one hundred and eighty six thousand miles per second would take one hundred and forty million years to come to the Earth. What further depths of space would be revealed if a 200-inch telescope now in contemplation is constructed! But even this will admit only about a million times as much light as an unaided eye. And it is at present beyond our comprehension what still bigger Supergalaxies and still greater Metagalaxies would not be revealed, when astronomical instruments improve further, and in what inconceivably gigantic dimensions Universes surrounding Universes would not be disclosed. In face of these staggering figures, the utter insignificance of Man's place in this vast Universe can be readily realised. This Outer World represents but one side of the range of human vision.

On the other side, we have the minutest particles constituting worlds within worlds. Matter has been found to consist of molecules of a hundred-millionth inch in diameter, so minute that a pint of water would contain twenty million, million, million, million molecules, the weight of each being of the dimension a million million million millionth fraction of an ounce. Each such molecule consists of two or more atoms. Some two hundred and fifty varieties of atoms (including isotopes) of smaller sizes have been discovered, which account for ninety different elements. In its turn, every atom consists of electrons and a nucleus. An electron has a radius of 5 million millionth part of a centimeter. It revolves round its nucleus several thousand million million times every second. The nucleus, though in fact much heavier, is so condensed that it is even smaller in size than an electron. But all these are heavier bodies as compared to light particles, if they at all exist.

To imagine the speed at which these may be vibrating it may be mentioned that an electron vibrates at the rate of 124 million million million complete oscillations per second. Protons constituting the nuclii may be vibrating at even a greater speed of 229 thousand million million million oscillations per second. As Science is making tremendous strides, it is impossible to hazard even a guess what further inner-most depths of the Inner World will not be disclosed very soon.

Standing somewhere perhaps mid-way between the Unknowns on the two sides, Man's power of observation is strictly limited between apparently very narrow limits. As scientific knowledge progresses, these limits will no doubt be extended further and further on both sides, and yet our knowledge will ever remain very meagre and scanty. We can only have mere glimpses of the vast expanse of Nature, and our theories are but conjectures and speculations as to the ultimate Reality. Yet in spite of all our hopeless imperfections, advance is being made rapidly in increasing geometrical progression. The last decade has brought about a tremendous revolution in scientific thought. The conception of the Universe as a great machine working in an ordered way has completely collapsed. Nature is now regarded as being capricious and arbitrary, and her processes as sudden jumps, and uncertain jerks, without following any methodical Law of Causation. The Law of Causation has been dethroned from the honourable position which it had previously occupied, and its prominent place has been taken by a new Law of Indeterminacy which inexorably lays down not only a subjective, but even an objective Uncertainty. Everything in the Universe is now believed to be comprised of mere imaginary waves of Probability and Chance, so that nothing substantial, tangible or real exists in it.

I propose to scrutinise the very basis upon which Modern Science has built this huge, but imaginary structure, by considering first the successive steps which have driven us into such a desperate and helpless position. The principal origin of the trouble lies in the conception of light, to which alone I shall confine myself. I may be permitted to begin with a historical background, showing how and why various theories have had to be abandoned, giving place to present day conceptions. As this assembly of learned men and women consist of Physicists as well as non-Physicists, I fear I cannot make myself intelligible, without a somewhat detailed survey.

It is not too much to presume that when the human mind became sufficiently developed, one of the very first wonders which would have struck it must have been the mystery of vision. Eyesight is our dearest possession. Half of the happiness of life would be gone if we lost our vision, and missed all the glories and beauties that surround us. Our very comprehension of the magnificent design of the Great Maker would be lamentably incomplete if we had no means of observing the multifarious manifestations of Nature. One

can imagine the ancient philosophers asking themselves some such questions as these: How are bodies visible though they are at a distance? How do we see things, which we cannot touch? How are various objects perceptible at all? How is there a connection between the eye which sees and the object seen? But no serious endeavour was made to answer them for ages.

The ancient thinkers believed in a multiplicity of divinities, and felt no difficulty in attributing every observed phenomenon to a direct intervention of the gods. There was a Sun god who was responsible for sending out all the light and heat from the Sun to the Earth, and there was a god of fire who gave us fire from which heat and light were produced on the Earth itself. Another god caused lightning and thunder. The ancient philosophers did not feel themselves called upon to investigate the origin of heat or light. They took it for granted that such phenomena were mere creations of divine beings. It is therefore not surprising that the great minds of the early Assyrian, Egyptian and Aryan philosophers were not concerned with the mysterious phenomenon of vision, for in it they hardly saw any mystery at all. The early Persians or Iranians in the same way regarded fire as a divine manifestation. When Zoroastrians worshipped the sacred fire, their learned men could not be expected to pry into the genesis of what to them was nothing short of a symbolical embodiment of the divine being. One can safely presume that up to the time of the religious leader Zoroaster زردشت (1000 B. C) there was no occasion to bestow any serious thought on the physical problem of light.

So far as available historical records show the credit of making the first attempt to tackle this question must go to the early Greek philosophers. In spite of their beliefs in super-human agencies they endeavoured to evolve some intelligible theories to explain the mystery of vision. The name of the great philosopher Pythagoras فیثا غورس (572-497 B. C.) stands out in eminence for being the first to put forward a rational hypothesis. In his conception of the Universe as consisting of spheres moving in perfect harmony round the earth as centre, producing beautiful tones of music, he regarded all objects as an integral part of the harmonious whole. He conceived that light consisted of small particles that were thrown out from the object seen and entered the eye and this caused vision. According to him the particles were continually projected into the pupil of the eye, and thereby enabled men to see things. He was undoubtedly the first propounder of what later on came to be described as the Corpuscular Theory of Light.

Some 100 years after, the great Italian philosopher Empedocles انبیذ قلیس (444 B C.), who belonged to the Pythagorean school, conceived the world as consisting of four fundamental elements, earth, water, air and fire عناصر اربعہ. He rightly regarded all luminous bodies as the seat of fire; but his conception of light was that vision was effected by something emitting from the eye itself which after meeting something else emanating from the object excited the

sense of sight. This curious view could not be completely exploded till the advent of photography in recent times which dispensed with the eye for the purposes of vision. About the same time Philolus فلالرس (430 B. C.) considered that all the heavenly bodies revolved about a "central fire" which, however, was not visible to the inhabitants of earth, as the earth's face was always turned away from it. All the same it was the source of all heat. Anaxagoras الكسا غورس (450 B. C.) reverted to the Pythagorean idea and regarded the Sun as a hot stone, from which light was emitted and believed that the moon shone by reflected light.

Another century later, Plato فلاطون (350 B. C.) the famous disciple of Socrates سقراطا (470-399 B. C.), but greater than his master, founded a new school of philosophy. Quite in keeping with his natural religious tendencies, his philosophic mind combined the Zoroastrean conception of the divine element in fire, the Pythagorean idea of emission from objects, the Empedoclian assumption of emission from the eye, and added something of his own. His idea of vision was that it was caused by three distinct elements (1) divine fire emerging from the eye (2) light of the Sun following on an object and (3) emanations from the object seen. A visual stream of divine fire or rays emitted by the eye united with the light of the sun, and together combined with the emanation from the object, and in that way completed the act of vision.

His greatest disciple Aristotle ارسطا طاليس (340 B. C.) for the first time put forward an entirely original hypothesis that light is not at all a material emission from a source, nor any emanation from the eye, but is a mere property of or due to an action of the medium between the eye and the object. This was without doubt the first known origin of the modern Wave Theory of light.

The notion of Euclid اقليد س (340 B. C.) was that vision was caused by the interaction of something given out from the eye with something given out by the luminous or illuminated body. He tried to refute the Pythagorean emission theory. In the time of Ptolemy بطليموس (70-147 A. D.) all these rival theories continued, but he was inclined to the Pythagorean idea and explained reflection and even refraction of light on that supposition. Epicurus ابيقورس and Lucretius لقر اطوس were supporters of what has been termed the quasi-tentacular theory, and imagined that we perceive objects by means of light in much the same way as we feel things by means of a stick.

Curiously enough this strange hypothesis survived for many centuries, until ultimately Alhazen محمد ابن الحسن ابن الهيثم (died in 1038 A. D.) an Arab scientist of Basra, definitely discarded the idea of any emission from the eye and laid down a mathematical theory of light based on the hypothesis that the cause of vision proceeds from the object itself. His conception was that it is not a single ray of light, as had been assumed up to his time, but a cone of rays that proceeds from the object to the eye. On this theory he explained

reflection and refraction of light. He also examined the anatomy of the eye and showed how with two eyes we see only one object, and also explained many optical illusions. He showed why there was an apparent increase in the diameter of heavenly bodies near the horizon, how distances can be judged by the different vertical angles of the cone of light. This was a great advance in the conception of light and his theory remained accepted in Europe for more than 500 years after him. The Latin translation of his work on Optics was available to Vitellio and Roger Bacon in the thirteenth century.

Even great scientists like Copernicus (1473-1543), Galileo (1564-1642) and Kepler (1571-1630), to whom modern Science owes so much, did not improve upon Alhazen's conception. But Descartes (1638) reverted to the Aristotelian idea of an action of the medium which was called æther. Great strides were made in scientific discoveries, and Romer (1667) established from observations of the eclipses of Jupiters' Satellites that propagation of light had a definite velocity which he measured. Descartes thought that light was due to pressure transmitted instantaneously through a perfectly elastic medium which filled all space, and that colour was the result of some sort of a rotatory motion of the particles of the æther. But it was Charles Huygens (1629-1695) who in 1678 propounded an elaborate wave theory, under which light was due to a mere wave motion in a medium called æther. He gave a complete theory in a definite form, showed how reflection and refraction take place, and accounted for even double refraction. He is unanimously regarded as the true founder of the Wave Theory of light.

Newton (1642-1727), however, remained unconvinced and adhered to the Corpuscular Theory of light, because Huygens' Wave Theory failed to explain satisfactorily the rectilinear propagation of light or the casting of shadows. But simultaneous reflection and refraction at a surface was an apparent difficulty in the way of the Corpuscular Theory. So Newton attributed to the corpuscles "periodic phases or fits of easy reflection and easy transmission," so that sometimes they are in a condition to be reflected and sometimes in a condition to be refracted. He had to assume the existence of the æther, and further that forces of repulsion in the case of reflection and of attraction in the case of refraction come into play. His assumption was that velocity when resolved parallel to surface remained unchanged, but when resolved along the normal was altered. This last assumption resulted in the necessary conclusion that the velocity of light in denser (more refracting) medium must be greater than in rarer (less refracting) one.

The Wave Theory did not replace the Corpuscular Theory till Young (1802) explained how there could be interference on Huygens' Wave Theory, which was not possible on Newton's Corpuscular Theory, and Fresnel (1820) announced how polarisation of light could be explained only on the Wave Theory by assuming that the vibrations in the æther are transverse and not

longitudinal. Both Young and Fresnel demonstrated how an undisturbed succession of waves of sufficient width would move as a beam, spreading out like a shower of particles, without appreciably bending sideways. In this way interference, diffraction and polarisation of light were also satisfactorily explained, for which Newton's Corpuscular Theory was wholly inadequate.

The essential difference between the Corpuscular and the Wave theories is well known. According to the former theory a luminous body continually emits very small corpuscles or particles in all directions. These, when projected from it, bodily travel, like an arrow or bullet, through space with the velocity of light. There is thus a bodily motion of these small corpuscles from one point to another in space, and they carry with them their kinetic energy or energy of motion. According to the latter theory there is an all-pervading medium called æther, the vibrations of which are light. No particle of the æther travels along, but there is a mere relative displacement or disturbance, which is passed on through space. The particles of the æther merely oscillate transversely, and are not at all translated forward longitudinally. The wave propagation resembles the propagation of vibration, when one end of a long steel rod is hit sideways and a vibration is felt at the other end, although in point of fact no particle of the steel rod has travelled from one end to the other.

The Wave Theory of light came to be accepted as a natural theory, because scientists were familiar with the propagation of sound waves and also water waves. Light could be easily imagined to be some sort of a wave, provided an invisible medium like the supposed æther could be invented. By 1850 Foucault and Fizeau established experimentally that the velocity of light in water was less and not greater than that in air. This was a death blow to Newton's Corpuscular Theory, and no option was apparently left but to fall back on the Wave Theory.

But the Wave Theory brought with it its own difficulties:—

(1) The existence of an æther was an indispensable condition, but the nature and properties of the imaginary æther were not easy to formulate. Different æthers had to be postulated for different purposes, as different properties were required to explain different phenomena. The only variety of æther that survived was the *luminous æther* as conceived by Huygens. (2) The first problem was whether this æther should be assumed to be a gas, a fluid or a *solid*. Air and fluids were not found to transmit transverse vibrations, as they offer practically no resistance to distortion. So scientists were compelled to assume that the æther was a *solid* body stretching throughout space. (3) But longitudinal vibrations were not observed at all, as no optical phenomenon indicated any vibrations normal to the wave front. Accordingly there was no option but to assume that (a) either the longitudinal vibration was

infinite, in which case the æther would be absolutely *incompressible*, or (b) that it was nil or zero, in which case the æther would be *contractile*, *i.e.*, offering a negative resistance to compression. (4) But as no displacement whatever can take place if the æther were rigid, it had to be assumed that the æther was an *elastic* solid. But it cannot be elastic without having *torsional rigidity*, *i.e.*, resistance to change of shape. (5) But as there can be no direction fixed in space, the æther must be *uniform* in all directions, and so it must be capable of all possible vibrations; and yet it had *only transverse* and not longitudinal vibrations. If there was a perfect uniformity of the æther inside a crystal, it would not adequately explain polarisation and double refraction. (6) It was found that light had a finite velocity. Mathematically the velocity of a wave propagation in an elastic solid is proportional to the square root of its elasticity divided by its density. So the æther must have (a) either *varying elasticity*, which would destroy its uniformity (b) or *varying density*, which would make it cease to be incompressible, (c) or both, in which case both the difficulties would remain. (7) It was also found that light travels through transparent bodies. So the medium of its propagation must penetrate through such bodies. But if the æther freely pervaded such bodies, then there was no satisfactory explanation why light should have *different velocities* in different bodies. But actually it has. (8) Further, if light is a mere vibration of the æther and the æther penetrates through all bodies and pervades them, there was no reason why most bodies should be *opaque* to light. (9) If the æther were a solid medium, particularly if incompressible, even though elastic, then bodies moving through it ought to experience some resistance, but *no resistance* can be noticed. (10) Again, either the æther inside a body is *affected* by the matter contained in it, or it is not. (a) If it is not, then all bodies ought to be transparent to light as it is a vibration of the æther and not of matter. (b) If it is, then the æther inside the body should be affected in one way only, and the velocities of light of all colours should be the same; but they are not so. (11) Now if the æther were a vast store-house of energy, it might well have a spontaneous motion sometimes, but it has *no spontaneous* motion as a source of light is indispensable. (12) If the æther were an elastic solid, the vibration once produced might well continue, even after the source of light is shut out. But there are no such subsequent *oscillations*. (13) Various other hypotheses were put forward from time to time, *e.g.*, (a) the æther is like an *elastic jelly*, (b) or a *turbulent fluid*, (c) or that matter is like *vortices* or eddies in a stream. (14) None of the apparently contradictory properties of the æther explained *gravitation*. (15) The most insoluble problem, however, was the *æther-drag* or drift of æther. If a material body moves through the ocean of æther, does it carry with itself the æther contained in it, or does it allow the æther to pass through it freely, and so leaves it behind?

The Wave Theory did not remain without another rival. Michael Faraday (about 1833) had conceived of an electrified particle as an octopus-like structure, throwing out tentacles in the form of lines of force forming tubes of force. The tentacles from two such particles somehow took hold of one another and either pulled or pushed one another, causing the forces of attraction or repulsion. Clerk Maxwell (1831-79) developed the idea mathematically and regarded these lines of force as being formed out of electric and magnetic forces. In his hands the properties of the old æther became somewhat transformed, and his electromagnetic field of force had tubes of force having tension and lateral pressure due to electric strain and stress. He regarded the æther around an electrified body as being charged with energy so as to be in a sense polarised. He showed that light was an electromagnetic phenomenon caused by some unknown periodic disturbance in the æther. His remarkable discovery was that the velocity of light was equal to the ratio of any electrical quantity measured in Electromagnetic and Electrostatic units respectively. He laid down a new Electromagnetic Theory of Light. But he could not dispense with the æther, though he gave different properties to it, and his theory also was in essence a Wave Theory. But the classical Wave Theory of light was put to severe experimental tests, and it failed because two different experiments gave exactly opposite results.

Owing to the motion of the earth relatively to a luminous heavenly body, a change called "*aberration*" must occur in the direction in which the waves of light from that body appear to travel, when viewed by an observer on the earth. As the earth revolves round the sun, the direction in which a star is seen would be different in different seasons. The stars appear to describe small orbits around their true positions, as a result of the orbital motion of the earth compounded with the velocity of light. But the velocity of light would differ according to the medium through which it passes, and would be reduced if a telescope were filled with water instead of air. In 1871 Airy and Hoek proved by experiment that the aberration of the fixed stars is the same whether the telescope is filled with water or with air. This result could be accounted for mathematically by the assumption that æther waves were *partly* carried along by the moving matter with a velocity reduced in the ratio $(1-\frac{1}{\mu^2})$ where μ is the refractive index; or else the angle of aberration would not be independent of the substance with which the telescope is filled.

On the other hand, in 1887, Michelson and Morley carried out an experiment to test the relative motion of the earth and the æther. If there were any relative motion, then the time taken by a ray of light to pass to and fro along a given distance parallel to the earth's motion would not be the same as that taken by a similar ray travelling over the same distance but perpendicular to

the earth's orbit. These rays can, therefore, be made to have different phases and would cause interference. But not the slightest sign of any displacement of the interference fringes was observable when the apparatus was rotated through an angle of 90°. The only possible conclusion was that the velocity of light is not in the least affected by the motion of the earth, and that therefore the æther in the neighbourhood of the earth did not remain at rest in space but was *wholly* carried along by the earth. Subsequent experiments also, including that of Trouton and Noble, have generally confirmed the same result. (Prof. Jauncey's *Modern Physics*, p. 446.)

In 1893-95 Fitzgerald and Lorentz put forward a hypothesis that the length of the measuring rod itself is altered with the motion of the rod, and that a rod held West to East in the direction of the motion of the earth contracts, and is smaller in length than if the same rod were held North to South at right angles to that motion. However startling the theory of the shortening of the measuring rod may appear, there was no other apparent explanation of the contradictory results obtained by the above experiments.

There was yet another experimental result which destroyed the old Wave Theory of light. The chief characteristic of a wave propagation is its continuity. Theoretically the energy of a radiation for a given temperature should be proportional to the inverse fourth power of the wave length. So with a decrease in the wave length λ the energy increases still more rapidly. This equation would give a continuously rising curve. Experimentally, cavity radiation, *i.e.*, black body radiation, which is a perfect kind of radiation as it has all colours, depends on the temperature of the body only and is independent of the material of the cavity. When the cavity radiation, passed through a prism was observed by means of a bolometer, it was found that as wave length decreased, the energy rose up to a maximum, and then fell again with further decrease. It was noticed that the greater the temperature, the more the maximum shifted towards the violet side. Thus the hotter the source, the nearer to the violet side is the concentration, *i.e.*, more violet rays are emerging. The wave length corresponding to the maximum of the curve was represented by Wien's law λ_m T=constant, where λ is the wave length for the maximum energy and T is the temperature. The old Wave Theory utterly failed to account for the occurrence of the maximum at an intermediate position, which could not occur in a continuously rising curve.

The result that followed is the well-known "violet catastrophy" showing almost an infinite energy for λ approaching zero. In the words of Sir James Jeans [*The Mysterious Universe*, p. 32]:

"If light consisted of waves like the waves of the sea, it can be shown that all the light of the analysed sunlight ought to be found at the extreme violet end of the spectrum. Not only so, but extreme violet light waves have an

unlimited capacity for absorbing energy, and as they have their mouths permanently wide open, all the energy of the Universe would rapidly pass into the form of violet or ultra violet radiation travelling through space."

With all these results it might well have been expected that at the end of the nineteenth century, there would be an abandonment of the Wave Theory; but as a particle theory was considered to be an impossible theory there was no help.

In 1900 Professor Planck announced his famous Quantum Theory. According to him the processes of Nature are by jumps or jerks in indivisible quantities. He regarded the process of light absorption as discontinuous For each wave length there is a definite associated quantity of energy. $E_{\nu}=h\nu$ is the fundamental equation in which h is a universal constant. This means that the size of a unit of energy depends on its frequency; for each frequency there is a distinct unit; and the greater the frequency the greater the energy. This assumption explained the occurrence as well as the shifting to the violet side of the maximum limit of energy with temperature. In 1905 Professor Einstein extended the idea to radiation as well. On this extended theory, a beam of light consists of discreet units, light quanta or photons. Light is propagated in unbroken photons, a fraction of a photon not being seen. Energy is always a complete photon or a multiple of photon, but not a fraction. Now one would have imagined that the conception that energy moves in indivisible quanta would have at once pointed the way to a particle theory. But simply because energy was measured in terms of frequency, and frequency was believed to be incompatible with any particle theory, the tenacious adherence to the Wave Theory continued, but it was coupled with a hypothesis of sudden jumps which would make it almost a particle theory.

The *Photo-electric effect* was another blow to the Wave Theory. If light of a definite frequency be thrown on a metal plate, electrons coming out of it have a sharp maximum velocity. It is found experimentally that (1) the velocity of such electrons is independent of the intensity of the falling light, while (2) the rate of the emission of electrons is proportional to intensity. This means that the velocity does not depend on the intensity at all, but depends on frequency only; the greater the frequency of the incident light, the greater the velocity of the emerging electrons. After this experimental result the Wave Theory again failed, because according to it the intensity ought to have controlled the velocity. But Prof. Einstein's explanation based on Planck's Quantum Theory came to the rescue. If light fell on the plate in quanta, and only one quantum was absorbed by an electron, then its velocity would be the same, so long as light of the same frequency was falling. The increase in intensity would merely increase the number of the electrons that are liberated, and not their velocity. It was assumed that out of the quantum of energy

absorbed, part was utilized in liberating the electron and the remainder gave to it kinetic energy. This explanation also in reality confirmed that light consisted of indivisible particles, as discontinuity is inconceivable in waves.

In 1905 Prof. Einstein first announced his epoch-making Theory of Relativity; the general theory was completed later in 1915-17. It was intended to explain the result obtained by Michelson and Morley, and is based on the assumption that the velocity of light is an absolute constant. Not only is it the utmost maximum possible, but the velocity of light measured by an observer on any moving body relative to himself is always the velocity of light itself, *i.e.*, light seems to him to take the same time to overtake him whether he is moving or is at rest. However fast the observer may be moving, his own velocity as compared to the velocity of light is always zero. As Prof. Jauncey (*loc. cit.*, p. 448) has put it, an observer on the earth, when measuring the velocity of light would find it the same as another observer on a planet moving with a speed half that of light relative to the earth. This is so, although the velocity of light is perfectly definite, *viz.*, $3 \cdot 10^{10}$ cm. per sec. So far this assumption has worked tolerably well within the Solar System. The theory of Relativity, as propounded by Prof. Einstein and Prof. Minkowski, does not directly touch the conception of light. It would, therefore, be quite out of place to discuss here whether a new interpretation of Relativity based on a different hypothesis is not theoretically possible.

Relativity has no doubt altogether changed the conception of æther. Scientists now avoid that word, and prefer to call it space endowed with certain properties. Some scientists go so far as to regard it merely as a frame of reference, and according to Sir James Jeans (*Mysterious Universe*, pp. 92-93) "it is a creation of thought, not of solid substance"—"a pure abstraction". Prof. C. G. Darwin (*New Conceptions of Matter*, pp. 23-24) considers that the æther has not been completely abolished, but is merely space endowed, among others, with the property of undulation—"it is a true universal carrier", and its business is to carry by its undulations energy placed in its charge. Sir A. S. Eddington (*The Nature of the Physical World*, p. 31) holds that although motion with respect to the universal ocean of æther eludes us and 'velocity through æther' is meaningless, "this does not mean that the æther is abolished. We need an æther. The physical world is not to be analysed into isolated particles of matter or electricity with featureless interspace. We have to attribute as much character to the interspace as to the particles, and in present day physics quite an army of symbols is required to describe what is going on in the interspace . . . The æther itself is as much to the fore as ever it was, in our present scheme of the world". Now if the interspace is not a mere void or vacuum, but possesses certain characters, the æther exists,

though we may give to it new properties which our new theories may now require. Indeed, if light is a mere wave motion, there being nothing material which is translated forward from point to point, then unless the whole thing is illusory, there must be some medium which vibrates or else the waves would not be carried along. It is immaterial whether we like to call it æther or space endowed with the property of undulation.

The discovery of the electron by Sir J. J. Thomson during the close of the last century followed by the announcement of the atomic system made by Lord Rutherford in 1911, that it consisted of electrons revolving round a nucleus concentrated as a tiny speck, might well have led on to such a hypothesis of light as one can picture in one's mind. But Professor Niels Bohr's electronic orbits, of definite sizes and shapes, without any intermediate orbits, and representing different levels of energy, put forward in 1913, helped to give to light a mere intangible character. Light was now nothing substantial, but a mere non-material energy, representing the difference of two levels of energy in the electronic orbits. Electrons go whirling round in definite orbits, and every now and then, quite spontaneously, jump suddenly from one orbit to another; this change of orbit implies a difference in levels of energy and this difference is represented by light. As Dr. Whitehead (*Science and the Modern World*, p. 164) has put it:

"The difficulty with the quantum theory is that, on this hypothesis, we have to picture the atom as providing a limited number of definite grooves, which are the sole tracks along which vibration can take place. . .".

One should have again imagined that the assumption of separate and distinct orbits, without any continuity would have been sufficient to demolish the Wave Theory. But this was still not to be.

Professor Einstein in 1917 carried the hypothesis still further right up to its logical conclusion. Planck's Quantum theory must destroy the Law of Causation itself. Now there was no such thing as cause and effect. There was an apparent capriciousness in Nature. It acted somewhat arbitrarily. One could not predict with certainty which of a number of possible states would follow a particular state. The whole thing was a mere matter of chance or probability, not certainty. The uncertainty is not due to our ignorance, but is natural and inherent. There is an increasing "randomness". On investigating the statistics of the jumps, Professor Einstein found that all could not be caused by heat or radiation, and that some of the jumps must necessarily be altogether spontaneous. Here was another opportunity for abandoning the Wave Theory, and not the Law of Causation. But the theory was too firmly planted in scientists' minds to be so easily dislodged. Still more startling experimental results confirming the particle theory were to follow before it could even be modified.

Experiments had established that (1) an α particle (which is the nucleus of a helium atom) can collide with a hydrogen nucleus, and the two dart off in

different directions. (2) Similarly an α particle colliding with a helium nucleus has been photographed, and (3) electrons are found to be scattered by atoms. But α and β particles and electrons were then still supposed to be mere particles. In 1923 Professor Compton discovered that X-rays when falling on electrons behave exactly like a swarm of particles, and are scattered as if material particles, moving as separate detached units, collide with electrons and are deflected like billiard balls. The calculation of energy of the photons after the hits verified not only the conservation of energy but also the conservation of momentum. Professor Compton found that the wave length of the scattered photon was lengthened after its collision with an electron, varying with the angle of scattering. The track of an electron, in recoiling from an X-ray, was photographed by means of the cloud produced in a chamber filled with water vapour. If all the conditions of energy and momentum, required by the Law of Dynamics, are satisfied by a photon, one wonders what more is required to prove that light is not a mere wave.

Reference has already been made to the photo-electric effect. The collision of a photon not only with an atom, but also with a molecule, has been established. If the photon of very short wave length, like X-rays, strikes an atom, then the force exerted on the outer electron being comparatively very great, the electron is knocked out and photo-electric effect is produced. On the other hand, those of longer wave lengths do not produce effect to the same extent. In 1928 Sir C. V. Raman observed the scattered light from a mercury arc when passed through a liquid, and found light not only of the same frequency but also of both higher and lower frequencies giving extra lines in the spectrum. Differences in frequencies between such extra lines and the original line corresponded to the frequency of the scattering molecules of the liquid. The result showed that the molecules absorbed just those quanta which had their own frequency, and let through the rest; and further that the effect of the collision of photons with the molecules was either (1) that the photon imparted some of its energy to the molecule, so that the scattered ray was of lower frequency or (2) that the molecule gave a part of its energy to the photon, so that the emerging photon had a higher frequency. This also showed that light behaved as separate units.

As the particle nature is now being denied even to an electron, it is convenient to mention at least one experimental result showing that electrons behave like a swarm of particles. This is *Scintillation*. A scintillating screen is made by lightly powdering a sheet of glass with zinc sulphide crystals. This substance has the property that if one of its crystals is struck by an electron, it gives out a spark, which however is so faint that it can be seen only in a dark room with the help of a magnifying lens. When the prepared screen is exposed to a stream of electrons, scintillations appear irregularly all over it. The behaviour is like that of shower of rain falling on the screen,

each scintillation being caused by a separate drop. The irregular scintillations *prima facie* disprove that there is any wave impinging on the screen.

All the above-mentioned experimental results unmistakably pointed to a particle structure of light and matter. But prejudice in favour of the Wave Theory was over a century old and still remained unshaken. But on any wave theory, waves must of a necessity go on constantly spreading indefinitely. Existence of fossils, which have lain buried in rocks for hundreds of millions of years, becomes utterly inexplicable. By this time they should have evaporated away in waves. But contrary to this classical conception of dispersing more and more, the fundamental fact of regathering of light into h-units stares us in the face. Attempts have been made to explain the contradiction by what are characterised as the "Collection-box" theory and "Sweepstake" theory. The first would correctly represent fractions of waves entering an atom in succession, but is admittedly untenable. The second is nothing more than the mere law of chance. Both have had to be used indiscriminately. The hesitating indecision to give exclusive preference either to the classical laws or the quantum laws has been described in an expressive way by Sir William Bragg, who has remarked that "we use the classical theory on Mondays, Wednesdays and Fridays, and the quantum theory on Tuesdays, Thursdays, and Saturdays." Sir A. S. Eddington has felt compelled to feel a little sympathy towards the man whose philosophy of the Universe takes one form on week-days and another form on Sundays. The fact is that in this state of uncertainty both the classical laws and quantum laws, though radically irreconcilable, are applied together. In the words of Sir A. S. Eddington, "the whole procedure is glaringly contradictory but conspicuously successful" (*loc. cit.*, p. 194). Prof. Bridgman's "Operational Viewpoint" now lays down that a concept is utterly meaningless, unless we at the same time describe the operation by which it is measured. It is merely the sum total of the operations used to measure it, and varies with the set of operations. (Jauncey, *loc. cit.*, pp. 534-39).

It must, however, be admitted that there were the two phenomena of interference and diffraction which remained outstanding and apparently proved the Wave Theory of light and made the old Corpuscular Theory an impossible one. Without doubt light can interfere and is also diffracted. The old theory cannot explain how it can do either; but the Wave Theory satisfactorily explains both.

Now although light was regarded as a mere wave motion, protons, electrons, atoms and molecules were considered as definite particles whose motions and positions could be pictured. But electrons were found to be diffracted, and also protons were found to be capable of being diffracted. It was discovered by Messrs. Davisson and Germer that electrons are systematically scattered from a sheet of nickel into certain definite directions, showing the peculiarity that would be due to the diffraction of X-rays by the crystals of

nickel. The closely-packed atoms of a solid body form a pattern and serve the purpose of a diffraction grating. Prof. G. P. Thompson applying the principle of "powder photograph" let a very narrow and straight pencil of electrons moving at a very high speed, fall on an extremely thin metallic film, so thin as to be nearly transparent, and then on to a photographic plate placed beyond the film. The image that was produced consisted of a central spot with circular rings round it, due to the diffraction of the electrons by the small crystals of the metallic film. Recently the diffraction of whole atoms has also been observed. It is not too much to predict that even molecules will soon be diffracted.

Now the position became irreconcilable. Some experiments definitely showed that photons, protons, electrons, and atoms behaved like solid particles, while others indicated that they behaved like waves. They behaved sometimes as particles and sometimes as waves, and there was no general principle yet known which could tell how they would behave. There was some sort of an apparent duality, so that photons, protons, electrons and atoms appeared to be both particles and waves. There remained only two possible courses open. It was like the horns of a dilemma :—

(A) Either not only atoms, electrons and protons, but also light should be regarded as particles and distinct individualities assigned to them. (B) Or one should not only deny individuality to light, but also deny it to protons, electrons and even atoms, and ultimately to molecules also. The conviction against the Corpuscular Theory was so firmly fixed that the choice was made per force of the second alternative.

In 1925 Prof. Heisenberg laid down the foundation of the New Quantum Mechanics or Matrix Mechanics, an entirely mathematical theory, adopting an algebraic method and using matrices, an advanced form of determinants. Prof. De Broglie introduced the idea of waves, though in a rather vague and general way. In 1926 Prof. Schrödinger developed the theory mathematically and applied the method of Differential Equations. In 1928 Prof. Dirac combined Relativity with Quantum Mechanics and laid down Equations known after his name. We have now a perfect system of Wave Mechanics so far as the mathematical aspects are concerned; but it has not even the faintest resemblance to a physical theory.

How the new theory explained interference, the principal cause of the trouble, which according to Prof. Dirac also cannot be explained on any particle theory at all, may be stated in his own words (*Wave Mechanics*, p. 15):

"The answer that quantum mechanics gives to the difficulty (of interference caused by a beam of light when split up into two components of equal intensity) is that one should consider each photon to go partly, into each of the two components, in the way allowed by the idea of the superposition of states. Each photon then interferes only with itself. Interference between two different photons can never occur."

In 1927 Prof. Heisenberg propounded a new Uncertainty Principle or Principle of Indeterminacy that it is wholly uncertain how an electron, for example, will behave. An electron is now supposed to be a train of waves stretching from infinity to infinity; the electron can be assumed to be anywhere in this train, only its speed is known, but its position is unknown. But once any one tries to observe it, the infinite train instantaneously contracts to a zero point, the position becomes known, but the speed becomes indeterminate. A wave group or wave train may have any size or shape; but the position is when known, the speed is indeterminate. A wave group or train must always be moving, it cannot be stationary, its shape also is constantly changing, the number of crests is also changing, generally speaking the number goes on increasing as time passes; the spreading is very rapid if the length of the region is very short, but it is slow in a long train. The train of waves representing an electron goes on spreading from infinity at one end to infinity at the other. But the moment the electron is attempted to be observed, its whole infinite train contract immediately to a zero point. It is supposed to be impossible to know with precision both the velocity and the position at one and the same time.

For an illustration, we may take one of the nearest stars like Sirius, which is fifty-one million million miles away, and from where light travelling at the rate of 186,000 miles per second takes over 8½ years to reach the earth. A quantum of light that starts from it in the form of waves will have spread out almost to immeasurable dimensions by the time it reaches the earth. So long as it has hit nothing, it has gone on expanding continually to an immense extent. But as only a whole quantum, and not any fraction of it, can enter an atom at a time, the result must be that as soon as that quantum in the form of an infinite wave hits an atom on the earth, the infinite train must instantaneously re-gather itself, and contract to almost a zero point; and in this way just one quantum of it enters the atom. The only feasible hypothesis put forward, which is more of an excuse than an explanation, is that only one aspect can be seen in one experiment at a time, and that no experiment has been or can be designed which will show both the particle and the wave aspects at one and the same time.

Prof. C. G. Darwin (pp. 79-80) has suggested an experiment in which a stream of electrons is sent out through two very small holes close together, and then scintillations looked for, which would most probably appear as isolated sparks, but the sparks would all occur in certain bands, and none at all where diffraction theory predicts darkness; but if one hole were stopped, the interference would be destroyed and there would be scintillations everywhere. I submit that in this way both interference bands and scintillation can be seen simultaneously on the same screen. These effects would be easily intelligible on a new particle theory, if light particles emerge

from electrons at fixed intervals corresponding to the periods of their rotations.

According to Sir James Jeans, as radiation, electrons and protons "can appear now as waves and now as particles", they "appear to be particles and waves *at the same time*". He adds, "Clearly we can only preserve our belief in the uniformity of nature by making the supposition that particles and waves are in essence the same thing". (p. 35) At another place (pp. 68-69) he says,. "Possibly we may come fairly to the truth if we think of matter and radiation as two kinds of waves—a kind which goes round and round in circles, and a kind which travels in straight lines. This may express the whole difference between matter and radiation, matter being nothing but a sort of congealed radiation travelling at less than its normal speed . . These waves are of two kinds, bottled up waves, which we call matter, and unbottled waves, which we call radiation or light... These concepts reduce the whole universe to a world of radiation, potential or existent". "Matter and radiation are found equally to resolve themselves into waves ... We live in a universe of waves, and nothing but waves."

But just to show what is meant by these waves, I may quote from Sir James Jean's latest book (*The New Background of Science*, pp. 241-42):

"We treat the waves as wave of probability, their extension in space defining the uncertainties of our knowledge. The waves are no longer waves of energy, but of the chance of finding energy . . . So, in the last resort, the waves which we describe as light waves, and those other waves which we interpret as the waves of an electron and a proton, also consist of *knowledge*—Knowledge about photons, electrons and protons respectively."

So unfortunately even these waves are not real waves at all, but purely imaginary and fictitious waves—mere waves of probability. These waves are not now even waves of energy, but only of chance, and so cannot be located in space and time, but are a mere something unthinkable expressed by mathematical equations only. This is the only way in which absurdities like the instantaneous regathering of light is tried to be explained. The waves are a mere mathematical fiction.

Prof. Heisenberg took up the idea that a wave motion can be expressed by means of an infinite Fourier's series, and by suitably selecting the co-efficients any kind of waves can be represented by a process of superposition. In this way a curve would be characterised only by a set of co-efficients in a given order With a view to secure some stability for an atom and to maintain Prof. Bohr's idea of sudden jumps from orbit to orbit, he used square matrices, an advanced form of determinants, to represent the wave motion. Prof. Einstein's and Prof. Minkowski's continuum had only four dimensions, three of space and one of time. But the Wave Mechanics requires a system of waves of seven dimensions to explain the behaviours of two

electrons, of ten dimensions to explain the behaviours of three electrons, and so on, in fact one plus three times as many dimensions as there may be electrons. The result of this mathematical manipulation is bound to be excellent, because the equations have been deliberately invented by a great mathematical mind to fulfil certain desired conditions; but it involves an abandonment of the commutative laws of multiplication. We had for long supposed that p multiplied by q is equal to q multiplied by p. But now the fundamental equation is that $p \times q - q \times p = \frac{h}{2\pi}\sqrt{-1}$ where h is the Planck's constant. Of course in such an equation p and q cannot be the ordinary arithmetical numbers; they are sets of numbers in certain orders. Sir A. S. Eddington on p. 207 remarks, "All authorities seem to be agreed that at, or nearly at the root of everything in the physical world lies this mystic formula. We do not yet understand that; probably if we could understand it, we should not think it so fundamental."

This basic formula for the modern conception of a light wave is interpreted differently by Prof. Born, Prof. Dirac and Prof. Schrödinger. According to Sir A. S. Eddington, "Schrödinger's theory is now enjoying the full tide of popularity, partly because of intrinsic merit, but also, I suspect, partly because it is the one of the three that is simple enough to be misunderstood. . . I do not see the least likelihood that his ideas will survive long in their present form". (pp. 210-11).

Prof. Schrödinger imagines something still more unreal than the æther, *viz.*, a sub-æther as a seat of some sort of oscillations, with beats; but "these beats are not themselves to be identified with light waves, they are in the sub-æther, whereas light waves are in the æther. The beats merely provide the oscillating source which in some way not yet traced sends out light waves of its own period." Sir A. S. Eddington's comment on this conception is "Schrödinger's wave-mechanics is not a physical theory but a dodge—and a very good dodge too. The fact is that the almost universal applicability of this wave-mechanics spoils all chance of our taking it seriously as a physical theory." (p. 219).

Prof. C. G. Darwin's opinion is that "the present theory of the interaction of light with matter is really rather unsatisfactory. The theory, in its final form due to Heisenberg and Pauli, is most extremely difficult; indeed it has been only in the hands of a few of the leading workers in this field that anything has been made of it, and it is, I think, rather widely felt that it is not founded on the right lines." (p. 159).

It is doubtful whether Sir J. J. Thomson really believes in the supposed waves of probability. His latest exposition is a hypothesis of granules moving with tremendous velocity and having a mass almost infinitesimal in comparison with an electron, their resultant attraction or

repulsion being due to the difference in the sense of rotation of vortex filaments.

Now once imaginary quantities like $\sqrt{-1}$ enter into the wave equation, we step out of the real world into an unreal world, and begin to express things by weird mathematical formulæ which can neither be pictured nor visualised. Physics then becomes a close preserve of the mathematicians, who deal with nothing but mathematical symbols, not capable of any intelligible physical interpretation. Solid matter disappears into something insubstantial, the tangible changes into the intangible, and the real into the imaginary. To quote Sir James Jeans again, "The essential fact is simply that all the pictures which science now draws of nature, and which alone seem capable of according with observational fact, are mathematical pictures. Most scientists would agree they are nothing more than pictures—fictions if you like, if by fiction you mean that science is not yet in contact with ultimate reality; . . . . . it is the general recognition that we are not yet in contact with ultimate reality." (p. 111).

It has also been remarked that "the Universe appears to have been designed by a pure mathematician" that "the final truth about a phenomenon resides in the mathematical description of it" and that what we know as light merely "exists in a mathematical formula; this, and nothing else, expresses the ultimate reality." As Dr. Whitehead (p. 143) has put it "Scientific thought is outrunning common sense." The consequences of the assumption that everything in this universe is a mere mathematical equation of an imaginary wave would make the concept a mere structure of pure thought incapable of realisation in any sense which can properly be described as material. In the words of Sir James Jeans, "The universe cannot admit of material representation, and the reason, I think, is that it has become a mere mental concept." "To-day there is a wide measure of agreement, which on the physical side of science approaches almost to unanimity, that the stream of knowledge is heading towards a non-mechanical reality; the universe begins to look more like a great thought than like a great machine. The old dualism of mind and matter . . . seems likely to disappear . . . through substantial matter resolving itself into a creation and manifestation of mind." (p. 137).

The situation cannot be summed up better than in the words of Sir A. S. Eddington, "Nowadays when enthusiasts meet together to discuss theoretical physics the talk sooner or later turns in a certain direction. You leave them conversing on their special problems or the latest discoveries; but return after an hour and it is any odds that they will have reached an all-engrossing topic—the desperate state of their ignorance. This is not a pose. It is not even scientific modesty, because the attitude is often one of native surprise that Nature should have hidden her fundamental secret successfully from such powerful intellects as ours. It is simply that we have turned a corner in the path of

progress and our ignorance stands revealed before us, appalling and insistent. There is something radically wrong with the present fundamental conceptions of physics and we do not see how to set it right." (p. 179).

So this is where the scientists have arrived! And why? Might it not be that over a hundred years ago the initial mistake was made and ever since that time it has been taken for granted that a particle theory of light is an impossible theory, and that, therefore, there is no option but to have a wave theory, howsoever imaginary the waves may be? Might it not possibly be that the rival theories were like the parting of ways, and the choice of the wrong path has led us into an arid desert, into which we have been lured because of the openness of space untrammelled by any obstacles, in preference to the dense and dark forest which had deterred us, but beyond which, if we had pierced through it, lay the beautiful vistas of rich gardens? Might it not be that the greater the progress we are now making at every step towards the imaginary goal, the more we are being drifted away from reality? The imaginary world in which, out of our own choice, we have landed ourselves bristles with greater anomalies than what were sought to be avoided, and is full of apparent absurdities. The present-day physicist's mind is hankering after something real—a new dynamical world, the equations to express which would not involve imaginary factors so as to make it entirely illusory. Mere mathematical formulæ, howsoever perfectly well they may work on paper, cannot satisfy the philosophic mind unless they evolve something comprehensible.

In this desperate state of affairs, a sceptic may be excused if he begins to doubt the very axioms on which the modern conceptions are based: Was Newton right when he conceived that a material body will continue to move for all time to come with the same constant velocity in a straight line so long as it is not disturbed by any force? Was Huygens correct in his belief that in the propagation of light nothing material travels from one point to another but, that there is an imaginary medium which merely vibrates? Were not physicists wrong when they considered an æther indispensable, which all at the same time was solid, elastic, torsionally rigid, incompressible or contractile, uniform in all directions and yet polarised, varying in density, wholly carried along by moving matter when æther is just outside it, but only partially carried along when contained inside the matter? Are we bound to assume that electrons and protons are the ultimate fundamental units of Nature, and that there are no smaller worlds within them? Did Professor Planck propound the truth when he stated that there was a certain arbitrariness in Nature, and that a wave motion can be discontinuous? Must we concur in Professor Einstein's assertion that the Law of Causation does not exist? Is he right in saying that the velocity of light relative to a moving observer is always the same, no matter how fast he is moving? Are we really to believe

that there is no such thing as force, that there is nothing else in the Universe except relative motion, and that space has higher dimensions, has properties other than mere voidness and is in itself curved? Should we necessarily accept Professor Heisenberg's Principle of Uncertainty and Indeterminacy? Are we compelled to believe with Professors Schrödinger and Dirac that this world is comprised of nothing but mere waves of probability? Is it really the case that the only possible way of understanding physical phenomena is by starting with a unit of time as $\sqrt{-1}$, and by abandoning the laws of multiplication? Have we now no option left but to regard the whole universe as a mere mental concept, and everything around us as nothing but a creation of the mind?

One feels an irresistible temptation to answer these questions by saying that the remarkable degree of perfection attained by the mathematical theories has been at the sacrifice of all philosophical thought, and that the wonderful accuracy of experimental results has been completely[1] at the expense of simplicity. No doubt a steam roller can most perfectly crush a flea but is it worth while employing such a heavy machinery for the purpose, if the same object can be attained by a much simpler process? Any method of reasoning which reduces the universe into something imaginary cannot furnish a satisfactory explanation of it. Man's instinct, I should think, would rebel against the notion that he is nothing but a system of imaginary waves, and is not a real entity.

Further researches alone will decide whether something simpler and more easy of comprehension cannot be had. As a way out of this impasse, last year, in all humility, I ventured to publish the details of a Rotational Theory of light as a part of a still more general theory, which may surmount the existing anomalies, explain all the known physical phenomena, and bring us back once again into the world of reality. Briefly speaking, that hypothesis is that light consists of material particles (called by me *radions*) which can emerge out of electrons only when their velocity is reduced to a limiting value C. These possess a wave motion in this way that besides their common longitudinal velocity C, and spins round their own axis, they also have different rotational motions corresponding to the revolutions of the electrons in their orbits from which they emerge. The forward motion is measured by the well known velocity of light, and the rotational motions by the periods of time during which they complete one revolution round the axis of their path. Their spin is at present not noticeable. The combined motion is a mere superposition of the three motions. The actual path of a radion is along a helix, a uniform curve round an ellipsoidal cylinder. The motion of a particle in a wave fashion shows both the particle and the wave aspects simultaneously, and reconciles the apparently contradictory experimental results. The formula $\lambda = C.\ t$ gives us all the results we want. Intensity is measured by the number of

radions per unit area in a cross-section and moving along the path. Reflection is easily explained by the impinging of radions on the atomic systems in a surface, and refraction by their piercing through the inter-spaces. The reflected beam will contain more of the light polarised in a plane parallel to the surface, and the refracted beam more of the light polarised in a plane perpendicular to it. Radions of one definite period will constitute a monochromatic light, in which exactly similar states will recur at intervals of time separated by the period, with the same maxima and minima in between. Permanent differences in phases will cause both interference and diffraction. For such effects, only a periodic motion is required, and nothing more. Molecules, atoms, electrons, protons and radions can all be diffracted. The rotational motions produce transverse vibrations explaining polarisation and double refraction. Radions rotating in planes almost parallel to the grains of a crystal are let through, while those perpendicular to it are stopped. Differences in colour are the result of the different rotational velocities. Decrease of velocity in denser media in which atoms are more closely packed is obvious. So is also pressure of light. Zeeman and Stark effects are explained by the effect of the field on the orbits of rotation, and Compton and Raman effects by the collision of radions with electrons, atoms or molecules. Similar rotational motions of electrons and protons can explain electrification, both negative and positive, and also explain an electric current, and that of emerging radions will explain electromagnetic induction. Electrons and protons will become particles of the same nature, the difference between them being merely rotational velocities, above and below a mean value. The supposed oscillations of electrons and protons are but angular rotations with circumferential velocity respectively less and greater than that of light. The rotational motions of molecules parallel to a fixed direction will explain magnetisation. Further, the constant angular momentum of a radion would explain the un-understood, mysterious "h". The constancy of "h" is a simple mathematical result of the rotation round an axis, which acts as a virtual central force. It crops up in every experiment because our measuring instrument is light And what is more, Nature need no longer be capricious or proceed by jumps. The sudden jumps from orbit to orbit are a necessary result of successive losses of mass due to the discharge of radions, which must be in multiples of one radion. The interval of time between successive emissions of radions from one atom in one tangential direction corresponds to the period of the revolution of the electron in its orbit. The difference in the losses of momenta caused by emissions on the inner and outer sides of two bodies will explain gravitation. With the restoration of the principle of Continuity, the objective Uncertainty will be removed and the Law of Causation re-enthroned !

Sir James Jeans (p. 69) has suggested that "radiation may ultimately prove to be merely matter moving with the speed of light, and matter to be

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radiation moving with a speed less than that of light. *But science is a long way from this as yet.*" I may be pardoned for being audacious enough to assert that that stage is within the reach of Science to-day.

On the occasion of Newton's last centenary, Prof. Einstein expressed the wish—"May the spirit of Newton's method give us power to restore unison between physical reality and the profoundest characteristic of Newton's teaching—strict causality." May I respectfully say that Omar Khayyam's philosophy holds good to-day, just as it did ever before :—

> "Yea, the first Morning of Creation wrote
> What the Last Dawn of Reckoning shall read."

VOTE OF THANKS BY PROF N. R. DHAR

I have great pleasure in proposing a hearty vote of thanks to Sir Shah Mohammad Sulaiman. It is an unique occasion for Indian science that an extremely busy Chief Justice of a big High Court is very keen on the advancement of science and learning. It is a matter of great gratification to us that we have been able to welcome Sir Shah Mohammad Sulaiman amongst us as a seeker of new knowledge. After an extremely brilliant career in the Universities of Allahabad and Cambridge in Mathematics, Sir Shah Mohammad Sulaiman went in for legal studies and pursuit of law in which he became a luminary in a short time, but he never forgot his alma mater and took an active part in the affairs of the Allahabad University for a number of years and we owe largely to him certain expansions in the science side of our university and the appointment of Dr. M. N. Saha, the Founder and first President of the Academy of Science, U. P.

I hope Sir Shah Mohammad Sulaiman's contribution to Mathematical Physics will be great credit to him as a man of science and a landmark in the development of Mathematical Physics in our country.

SECOND VOTE OF THANKS BY Dr. H. R. MEHRA

I have great pleasure in seconding the vote of thanks moved by my colleague Dr. N. R. Dhar. We are highly indebted to Sir Justice Sulaiman for presiding over the annual meeting of the Academy and his illuminating address. It is very kind of him to find time in the midst of his arduous duties as the Chief Justice of the High Court to come here and honour us by his presence. The U. P. Academy of Sciences, which is in a state of infancy, needs the fostering care not only of well-known scientists but also of eminent scholars and statesmen. I am sure that it will gain considerably from the words of encouragement and inspiration, which we have received from Sir Sulaiman to-day. In him we find a rare and unique combination of a scientist, scholar and administrator of laws and it is a great boon that we can depend upon him for help and advice whenever we need it. The U. P. Academy of Sciences stands for advancement in scientific knowledge, which will not only bring material prosperity to these Provinces, but it is also bound to alleviate the sufferings of mankind.

It is a great privilege to me to second the proposal for vote of thanks which I do most gladly.

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Business Supplement

ANNUAL MEETING

The Annual Meeting of the Academy of Sciences was held in the Vizianagram Hall, Muir College Buildings, Allahabad, at 4 p. m. on Saturday, January 20, 1934. The Hon'ble Sir Shah Sulaiman, Kt., M.A., LL.D., Chief Justice, High Court, Allahabad, presided over the function. Prof. A. C. Banerji, the General Secretary, read the Annual Report of the Academy of Sciences for 1933.

Dr. K. N. Bahl, D. Sc., D. Phil., the President of the Academy, read his address. The Hon'ble Sir Shah Sulaiman then delivered his speech.

Prof. N. R. Dhar proposed a vote of thanks to the Hon'ble Sir Shah Sulaiman and Dr. H. R. Mehra seconded the vote of thanks.

SECRETARIES' REPORT

We have the honour to submit the following report on the working of the Academy during the period beginning from the 1st of January, 1933, and ending on the 31st of December, 1933.

The Second Annual meeting of the Academy of Sciences was held in the Vizianagram Hall, Muir College Buildings, Allahabad, on Friday, January 13, 1933. The Hon'ble Mr. J. P. Srivastava, the Minister of Education, presided over the function. His Excellency Sir William Malcolm Hailey, the PATRON of the Academy, whose keen interest and affection for the Academy are well-known, sent an inspiring message of hope and encouragement to the members of the Academy.

The Academy is making steady progress and has acquired a definite status in the eyes of the Scientists in India and abroad. It has now on its roll 117 members of whom 27 are non-resident members. Dr. S. S. Bhatnagar of Lahore was elected a Fellow of the Academy. We are much indebted to Government for the non-recurring grant of Rs. 2,000 which we received during the current financial year.

We are glad to mention that the Bulletin of the Academy has attained a high level of achievements and has been well received in the scientific world.

We are now receiving in exchange 99 Foreign and [illegible] compared to 53 Journals last year. 'NATURE', the well-know[illegible] journal of Great Britain, remarks in its issue dated 23rd of September, 1933, "The original memoirs published in the issues of the Academy represent a high standard of achievements." As the number of original papers submitted to the Academy is steadily increasing, it has become necessary to increase the size of the Bulletin and if possible to publish six issues of the same in each year instead of four as at present. Moreover the necessity of publishing a popular scientific journal is keenly felt. We shall have also to organise a scientific library for the province. But we are unable to give effect to our ideas and extend the sphere of our useful activities with the present non-recurring grant of Rs. 2,000 per annum. We hope and trust that Government will place us under further obligation by sanctioning a recurring grant of Rs. 4,000 per annum.

We are also indebted to the University of Allahabad for a grant of Rs. 500 during the current year, and shall approach also the other Universities of these Provinces for suitable grants. The need for a building of the Academy is urgently felt, and an appeal for raising money for this purpose will soon be issued. We shall require a Lecture Hall, a Reading Room, a Library and an Office in this building.

The thanks of the Academy are due to the Hon'ble Minister of Education, U. P., for founding a Gold Medal to be awarded to the author of the best paper published in the Bulletin in any year. The rules for the award of the medal have been framed.

The Academy welcomed the proposal of its Council that the name of the Academy of Sciences, U. P., be changed to the Indian Academy of Sciences. Dr. M. N. Saha, as the General President of the Indian Science Congress, 1934, was asked to bring the above resolution to the notice of the Scientists, who assembled at Bombay, and to discuss the whole question with them.

The General Committee of the Indian Science Congress at Bombay decided in favour of founding an Indian Academy of Sciences, and a committee has been formed to frame the constitution of the above Academy, and to take necessary steps for bringing into existence. The Academy of Sciences, U. P., has been invited to send a representative to serve in this committee.

The Academy conveyed its respectful felicitations to His Excellency Sir William Malcolm Hailey, the Patron of the Academy, on the conferment of the degree of Doctor of Laws by the University of Allahabad, for his eminent services to the cause of scientific research and education.

Our thanks are due to Mr. Narendranath Ghatak, M.Sc., for kindly helping us in the publication of the Bulletin. We also wish to express our thanks to the other office-bearers and the members of the Council of the Academy for their ungrudging help and active co-operation.

ABSTRACTS OF THE PROCEEDINGS

The list of the Office-Bearers and Members of the Council to which the management of the affairs of the Academy was entrusted for the year 1933-34 is given in appendix A.

Appendix B contains the list of names of 117 members who were on the roll of the Academy on March 31st, 1934.

The Council expressed its deep gratitude to the Government for the non-recurring grant of Rs. 2,000 awarded to the Academy for the year 1933-34.

It was resolved that provided the Government of the United Provinces have no objection, the name, "The Academy of Sciences of the United Provinces of Agra and Oudh" be changed to "The Indian Academy of Sciences."

The Council expressed its gratefulness to the Hon'ble Minister of Education, U. P., for founding a Gold Medal to be awarded to the author of the best paper published in the Bulletin in any year, and framed the following rules for its award:—

1. The medal will be awarded annually, provided in the opinion of the Council there is a candidate whose work is of sufficient merit.

2. The medal will be awarded in a particular year in one of the five groups of subjects mentioned below.

The group of subjects will be taken in rotation, provided that if no award is made in any particular year, the Council may award the medal for the group of the year in any subsequent year.

The following are the five groups of subjects:—

(i) Zoology and Medicine. anthropology
(ii) Mathematics and Astronomy.
(iii) Physics and Engineering.
(iv) Chemistry and Technology.
(v) Botany, Agriculture and Geology.

3. A person to whom a medal has been awarded once shall not be eligible for it a second time.

4. The medal shall be awarded on the basis of the merit of the paper published in the Bulletin or Journal of the U. P. Academy of Sciences, or in any other publication of the Academy.

5. The Council of the Academy shall ordinarily appoint three judges who must be experts in the subject to consider the award of the year.

Each judge shall submit his report separately and without consulting the other judges to the Council in a sealed cover marked "Confidential."

The President of the Council or in his absence the Vice-President or a Secretary shall open the covers in the presence of the members of the Council. The Council shall, after considering the reports of the judges, decide

upon the relative merits of the candidates for the medal and resolve upon the person to whom the medal should be awarded. If in the opinion of the Council no candidate deserves the award of the medal, it may withhold the award of the same.

While considering the reports of the Judges, the Council may, if it so desires, take into consideration at its own initiative any other work published by the Academy even the author of such a work has not submitted it for the award of the medal.

6. The Secretary will invite the authors to submit their papers for the medal by the end of July each year. The Council shall appoint the judges in August and the Secretary will submit the papers to them by the middle of September. The judges shall submit their reports by the end of October, and the Council shall decide the award at its Annual Meeting in November. The medal will be presented to the successful competitor in the Anniversary Meeting, and a statement of the grounds on which the award has been made will be made by the President.

7. A member of the Council so long as he remains a member, will not be eligible for the medal.

8. Only Members and Associates will be eligible for the medal.

9. No award shall be made merely on the basis of joint paper, but joint paper may be taken into consideration by the judges in considering the award.

10. In any matter not provided for here considering the award of the medal, the decision of the Council shall be final.

The following one member was elected Fellow of the Academy in the Fellow's meeting held on November 8, 1933:

1. Dr. S. S. Bhatnagar, D.Sc., Professor of Chemistry, Government College, Lahore.

The following members were elected Office-Bearers and the Members of the Council for the year 1934 in the Annual Meeting held on January 20, 1934:

President :

1. Prof. K. N. Bahl, D. Sc., D.Phil.

Vice-Presidents :

2. Prof. M. N. Saha, D.Sc., F.R.S., F.A.S.B., F.Inst.P., P.R.S.
3. Prof. B. Sahni, D.Sc., Sc. D., F.L.S., F.A.S.B.

Honorary Treasurer :

4. Prof. D. R. Bhattacharya, M.Sc., Ph.D., D.Sc., F.Z.S.

General Secretaries:

5. Prof. P. S. MacMahon, B.Sc., M.Sc., F.I.C.
6. Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S.

Foreign Secretary :

7. Prof. N. R. Dhar, D.Sc., F.I.C., I.E.S.

Other Members of the Council:

8. Prof. Nihal Karan Sethi, D.Sc.
9. Dr. S. S. Nehru, M.A., Ph.D., I.C.S., M.L.C.
10. Prof. C. A. King, B.Sc., A.R.C. Sc., M.I.M.E.
11. Prof. Ch. Wali Mohammad, M.A., Ph.D , I.E.S.
12. Dr. H. R. Mehra, Ph.D.
13. Prof. Rudolf Samuel, Ph.D.
14. Dr. S. M. Sane, B.Sc., Ph.D.
15. Prof. C. Maya Das, B.Sc., M.A., I.A.S.
16. Prof. K. C. Pandya, D.Sc.

APPENDIX A

LIST OF OFFICE-BEARERS AND MEMBERS OF THE COUNCIL 1933

President :

1. Prof. K. N. Bahl, D.Sc , D. Phil.

Vice-Presidents :

2. Prof. M. N. Saha, D.Sc., F.R.S , F.A.S.B., F. Inst. P., P.R.S.
3. Prof. B. Sahni, D.Sc., Sc.D., F.L S., F.A.S.B.

Hony. Treasurer :

4. Prof. D. R. Bhattacharya, M.Sc., Ph.D., D.Sc., F.Z.S.

General Secretaries :

5. Prof. P. S. MacMahon, B.Sc., M.Sc., F.I.C.
6. Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S.

Foreign Secretary :

7. Prof. N. R. Dhar, D.Sc., F.I.C., I.E.S.

Other Members of the Council :

8. Prof. K. C. Mehta, Ph.D., M.Sc.
9. Dr. S. S. Nehru, M.A., Ph.D., I.C.S., M.L.C.
10. Prof. Ch. Wali-Mohammad, M.A., Ph.D., I.E S.
11. Prof. K. K. Mathur, B.Sc., A.R.S.M.
12. Dr. P.L. Srivastava, M.A.; D. Phil.
13. Prof. Robert F. Hunter, D.Sc., Ph.D.
14. Dr. S. M. Sane, B.Sc., Ph.D.
15. Prof. C. Maya Das, B.Sc., M.A., I.A.S.
16. Prof. K. C. Pandya, D.Sc.

APPENDIX B

ORDINARY MEMBERS

R—Resident. N—Non-Resident.

*—Denotes a Fellow.

Alphabetical List of Ordinary Members

Date of Election		
17-4-1931	R	Asundi, (R.K.), Ph.D., Reader, Physics Department, Muslim University, Aligarh.
21-12-1931	N	Bagchi, (S.C.), B.A., LL.D., Principal, Law College, Calcutta
1-1-1930	R*	Bahl, (K.N.), D. Phil, D.Sc., Professor of Zoology, Lucknow University, Lucknow
1-1-1930	R*	Banerji, (A.C.), M.A., M.Sc., F.R.A.S, I.E.S., Professor of Mathematics, Allahabad University, Allahabad.
29-2-1932	R	Banerji, (G.N.), The Scientific Instrument Company Ltd, Albert Road, Allahabad.
22-12-1932	N	Banerji, (S.K.), D.Sc., Meteorological Office, Ganeshkhind Road, Poona 5.
17-4-1931	N	Basu, Saradindu, M.Sc., Meteorologist, Ganeshkhind Road, Poona 5.
19-3-1931	R	Bhargava, Saligram, M.Sc., Reader, Physics Department, Allahabad University, Allahabad.
17-4-1931	R	Bhargava, Vashishta, M.Sc., I.C.S., Assistant Magistrate and Collector, Budaun.
17-4-1931	R	Bhatia, (K.B.), I.C.S., Joint Magistrate, Shahjahanpur.
21-4-1933	N*	Bhatnagar, (S.S.), D.Sc., Professor of Chemistry, Government College, Lahore.
1-1-1931	R*	Bhattacharya, (D.R.), M.Sc., Ph.D., Docteur ès Sciences, Professor of Zoology, Allahabad University, Allahabad.
17-4-1931	R	Bhattacharya, (D.P.), M.Sc., Bareilly College, Bareilly.
3-4-1933	R	Chand, Tara, M.A., D. Phil., Principal, K. P. University College, Allahabad.
29-2-1932	R	Charan, Shyama, M.A., M.Sc., Agra College, Agra.
1-1-1930	R*	Chatterji, (G.), M.Sc., Meteorologist, Upper Air Observatory, Agra.
17-4-1931	R	Chatterji, (K.P.), M.Sc., A.I.C., F.C.S., Reader, Chemistry Department, Allahabad University, Allahabad.
17-4-1931	R	Chatterji, (A.C.), D.Sc., Chemistry Department, Lucknow University, Lucknow.

Date of Election.		Alphabetical List of Ordinary Members
9-2-1934	R	Chaturvedi, Champa Ram, Pandit, Professor of Mathematics, St. John's College, Agra.
19-3-1931	R	Chaudhury, Rabindra Nath, M.Sc., M.A., Mathematics Department, Allahabad University, Allahabad.
17-1-1931	R	Chaudhury, (H.P.), M.Sc., Lucknow University, Lucknow.
19-3-1931	R	Das, Ramsaran, D.Sc., Zoology Department, Allahabad University, Allahabad.
17-4-1931	R	Das, C. Maya, M.A., B.Sc., I.A.S., Principal, Agricultural College, Cawnpore
28-10-1932	N	Das, (A.K.), D.Sc., Alipore Observatory, Alipore, Calcutta.
22-12-1932	N	Das, (B.K.), D.Sc., Professor of Zoology, Osmania University, Hyderabad, Deccan.
15-9-1931	R	Dasannacharya, (B.), Ph.D., Professor of Physics, Benares Hindu University, Benares.
17-4-1931	R	Deodhar, (D.B.), Ph.D., Reader, Physics Department, Lucknow University, Lucknow.
17-4-1931	R	Dey, (P.K.), M. Sc., I.A.S., Plant Pathologist to Government, United Provinces, Nawabganj, Cawnpore.
29-2-1932	R	Deb, Suresh Chandra, D.Sc., Physics Department, Allahabad University, Allahabad.
1-1-1930	R*	Dhar, (N.R.), D.Sc., Docteur ès Sciences, F.I.C., Professor of Chemistry, Allahabad University, Allahabad.
1-1-1930	R*	Drane, (H.D.H.), M.Sc., Ph.D., A.M.I.E.E., A.M.I. Chem. E., Principal, Harcourt Butler Technological Institute, Cawnpore.
19-3-1931	R	Dutt, (S.K.), M.Sc., Zoology Department, Allahabad University, Allahabad.
17-4-1931	R	Dutt, (S.B.), D.Sc., Reader, Chemistry Department, Allahabad University, Allahabad.
28-10-1932	R	Dutt, (A.K.), D.Sc., Benares Hindu University, Benares.
17-4-1931	R	Forman, (D.N.), M.D., Jumna Dispensary, Allahabad.
22-2-1933	R	Ghatak, Narendranath, M.Sc., Chemistry Department, Allahabad University, Allahabad.
19-4-1931	R	Ghosh, (B.N.), M. Sc., St. Andrew's College, Gorakhpur.
8-11-1933	N	Ghosh, (J.C.), D.Sc., The University, Dacca.
19-3-1931	R	Ghosh, (R.N.), D.Sc., Physics Department, Allahabad University, Allahabad.
19-3-1931	R	Ghosh, Satyeshwar, D.Sc., Chemistry Department, Allahabad University, Allahabad.
15-9-1931	N	Gogate, (D.V.), M.A., Baroda College, Baroda.

Date of Election		Alphabetical List of Ordinary Members
15-9-1931	R	Gordon, (C.B.), B.A., Christ Church College, Cawnpore.
17-4-1931	R	Gupta, (B.M.), D.Sc., Deputy Public Analyst to Government, United Provinces, Lucknow.
21-12-1931	R	Hansen, (W.J.), M.A., Allahabad Agricultural Institute, Naini, E.I.R., Allahabad.
17-4-1931	R	Higginbottom, Sam, D. Phil., Principal, Allahabad Agricultural Institute, Naini, E.I.R., Allahabad.
17-4-1931	R*	Hunter, Robert (F.), D.Sc., Ph.D., Professor of Chemistry, Muslim University, Aligarh.
21-12-1931	R	Joshi, (S.S.), D.Sc., Professor of Chemistry, Benares Hindu University, Benares.
15-9-1931	N	Kichlu, (P.K.), D.Sc., Department of Physics, Government College, Lahore.
1-1-1930	R*	King, (C.A.), B.Sc. (Hons.), A.R.C.Sc., M.I.M.E., Principal, Engineering College, Benares Hindu University, Benares.
21-4-1933	N	Kishen, Jai, M.Sc., Professor of Physics, S.D. College, Lahore.
17-4-1931	R	Koshambi (D.D.), M.A., Department of Mathematics, Muslim University, Aligarh.
9-2-1934	N	Kothari, (D.S.), M.Sc., Ph.D., Professor of Physics, The University, Delhi.
5-10-1933	R	Kureishy, (A.M.), M.A., Reader in Mathematics, Muslim University, Aligarh.
1-1-1930	R*	Luxmi Narayan, D.Sc., Reader, Mathematics Deparment, Lucknow University, Lucknow.
1-1-1930	R*	MacMahon, (P.S.), B.Sc. (Hons.), M.Sc., Professor of Chemistry, Lucknow University, Lucknow.
1-1-1930	R*	Mathur, (K.K.), B.Sc. (Hons.), A.R.S.M., Professor of Geology, Benares Hindu University, Benares.
1-1-1930	R*	Mehta, (K.C.), Ph.D., M.Sc., Agra College, Agra.
1-1-1930	R*	Mitter, (J.H.), M.Sc., Ph.D., Professor of Botany, Allahabad University, Allahabad.
15-9-1931	R	Mathur, (L.P.), M.Sc., St. John's College, Agra.
8-11-1933	N	Mathur, Ram Behari, M.Sc., Professor of Mathematics, St. Stephen's College, Delhi.
19-3-1931	R	Mazumdar, Kanakendu, D.Sc., Physics Department, Allahabad University, Allahabad.
19-3-1931	R*	Mehra, (H.R.), Ph.D., Reader, Zoology Department, Allahabad University, Allahabad.
21-12-1931	R	Mehta, (N.C), I.C.S., Director of Agriculture, United Provinces, Lucknow.

Date of Election.		Alphabetical List of Ordinary Members
21-4-1933	N	Mela Ram, M.Sc., Asst. Professor of Physics, Foreman Christian College, Lahore.
21-4-1933	R	Mukerjee, (A.C.), M.A., Philosophy Department, Allahabad University, Allahabad.
21-4-1933	N	Mukerjee, Ashutosh, M.A., Professor of Physics, Science College, P. O. Bankipore (Patna.)
17-4-1931	R	Mukerjee, (S.K.), M.Sc., Agra College, Agra.
17-4-1931	R	Mukerjee, (S.K.), D.Sc., Reader, Botany Department, Lucknow University, Lucknow.
19-12-1933	R	Naithani, (S.P.), M.Sc., Botany Department, Allahabad University, Allahabad.
22-2-1933	R	Narliker, (V. V.), M.A., Professor of Mathematics, Benares Hindu University, Benares.
17-4-1931	R	Nehru, (S. S.), M.A., Ph.D., I.C.S., M.L.C., Deputy Secretary to Government, U.P., Publicity Department, Lucknow.
17-4-1931	R	Panday, (K.C.), D.Sc., St. John's College, Agra.
3-4-1933	N	Parija, (P. K.), M.A., I.E.S., Ravenshaw College, Cuttack.
5-10-1933	R	Prasad, Gorakh, D.Sc., Reader in Mathematics, Allahabad University, Allahabad.
21-4-1933	N	Prasad, Kamta, M.A., M.Sc., Professor of Physics, Science College, P.O. Bankipore (Patna).
15-9-1931	N	Prasad, Mata, D.Sc., Royal Institute of Science, Bombay.
3-4-1933	R	Prasad, Badrinath, Ph.D., Docteur ès Sciences, Mathematics Department, Allahabad University, Allahabad.
17-4-1931	R	Puri, (B.D), M. A., Thomason Civil Engineering College, Roorkee.
22-12-1932	N	Qureshi, (M.), M.Sc., Ph.D., Professor of Chemistry, Osmania University College, Hyderabad, Deccan.
3-4-1933	R	Raja Ram, M.A., B.E., Principal of Civil Engineering, Thomason College, Roorkee, U.P.
19-3-1931	R	Ranjan, Shri, M.Sc., Docteur ès Sciences, Reader, Botany Department, Allahabad University, Allahabad.
15-9-1931	N	Rao, A. Subba, D.Sc., Medical College, Mysore
22-2-1933	N	Rao, G. Gopala, B.A., M.Sc., Chemistry Department, Andhra University, Waltair.
21-12-1931	R	Rao, D. H. Ramchandra, B.E., A.M.I.E., Engineer, Allahabad University, Allahabad.
22-2-1933	N	Ray, Bidhubhusan, D.Sc., 92 Upper Circular Road, Calcutta.
21-12-1931	R	Ray, Satyendra Nath, M.Sc., Physics Department, Lucknow University, Lucknow.

Date of Election		Alphabetical List of Ordinary Members
1-1-1930	R*	Richards, (P.B.), A.R.C.S., F.E.S., Entomologist to the Government, United Provinces, Cawnpore.
1-1-1930	R*	Saha, (M. N.), D.Sc., F.R.S., F.A.S.B., F. Inst. P., P.R.S., Professor of Physics, Allahabad University, Allahabad.
29-2-1932	R	Saha, Jogendra Mohan, M.Sc., Manager, Srikrishna Desi Sugar Works, Jhusi, (Allahabad).
1-1-1930	R*	Sahni, (B.), D.Sc., Sc.D., F.L.S., F.A.S.B., Professor of Botany, Lucknow University, Lucknow.
17-4-1931	R*	Samuel, Rudolf, Ph.D., Professor of Physics, Muslim University, Aligarh.
17-4-1931	R	Sane, (S.M.), B.Sc., Ph.D., Reader, Chemistry Department, Lucknow University, Badshah Bagh, Lucknow.
21-12-1931	R	Sathe, (J.L.), I.C.S., Finance Secretary to Government, U. P., No. 1, Secretariat Quarters, Lucknow
3-4-1933	R	Sen, (K. C.), D.Sc., Imperial Institute of Veterinary Research, Muktesar, Kumaun.
21-4-1933	N	Seth (J.B.), M.A., Government College, Lahore.
17-4-1931	R	Seth, (S.D.), M.Sc., Christ Church College, Cawnpore.
1-1-1930	R*	Sethi, (R.L.), M.Sc., M.R.A.S., Economic Botanist to Government, United Provinces, Cawnpore.
19-3-1931	R	Sethi, Nihal Karan, D.Sc., Agra College, Agra.
15-9-1931	R	Sharma, Ram Kishore, M.Sc., Physics Department, Ewing Christian College, Allahabad.
3-4-1933	N	Siddiqi, (M.R.), Ph D. Professor of Mathematics, Osmania University, Hyderabad, Deccan.
3-4-1933	R	Siddiqui, Mohd. Abdul Hamid, M. B. B. S., M. S., F. R. C. S., D. L. O., Professor of Anatomy, King George's Medical College, Lucknow.
17-4-1931	R	Singh, Avadesh Narain, D.Sc., Department of Mathematics, Lucknow University, Lucknow.
17-4-1931	N	Soonawala, (M.F.), M.Sc., Maharaja's College, Jaipur (Rajputana).
19-3-1931	R*	Srivastava, (P.L.), M.A., D.Phil., Reader, Mathematics Department, Allahabad University, Allahabad.
10-8-1933	R	Srivastava, (R. C.), B.Sc., (Tech.) Sugar Technologist, Imperial Council of Agricultural Research, India, Cawnpore.
15-9-1931	N	Srikantia, (C.), B.A., D.Sc., Medical College, Mysore.
19-12-1933	R	Strang, (J.A.), M.A., B.Sc., Professor of Mathematics, Lucknow University, Badshah Bagh, Lucknow.

Date of Election		Alphabetical List of Ordinary Members
24-1-1933	N	Subramanian, (S.), M.A., Mathematics Department, Annamalai University, Annamalainagar P. O., South India.
17-4-1931	R	Sulaiman, (S.M.), Hon'ble Sir, Chief Justice, High Court, Allahabad.
19-3-1931	R	Taimini, Iqbal Kishen, Ph.D., Chemistry Department, Allahabad University, Allahabad.
19-3-1931	R	Tewari, Shri Govind, M.A., Mathematics Department, Allahabad University, Allahabad.
3-4-1933	R	Thompson, (C. D.), M.A., Professor of Economics, Allahabad University.
19-3-1931	R	Toshniwal, (G.R.), M.Sc., Physics Department, Allahabad University, Allahabad.
9-2-1934	R	Vaugh, Mason, B.Sc.·Ing., Agricultural Engineer, Allahabad Agricultural Institute, Naini, E.I.Ry. (Allahabad).
19-3-1931	N*	Vijayaraghavan, (T.), D.Phil., Reader, Mathematics Department, Dacca University, Ramna, Dacca.
1-1-1930	R*	Wali Muhammad, Ch., M.A., Ph.D., I.E.S, Professor of Physics, Lucknow University, Lucknow.
15-9-1931	R	Wall, (W. G. P.), M.Sc., I.E S., Associate I.E.E., M.R.S.T., Inspector of Schools, Allahabad Division, Allahabad

N.B.—The Secretaries will be highly obliged if the members will kindly bring to their notice errors, if there be any, in their titles, degrees, and addresses.

LIST OF MEMBERS OF THE PUBLICATION COMMITTEES 1933.

Mathematics

1. Prof. A C. Banerji, M.A., M.Sc., F.R.A.S., I.E.S., Professor of Mathematics, Allahabad University, Allahabad.

Physics

2. Prof. M. N. Saha, D.Sc., F.R.S., Professor of Physics, Allahabad University, Allahabad.
3. Prof. Ch. Wali Mohammad, M.A., Ph.D., I.E.S., Professor of Physics, Lucknow University, Lucknow.

Chemistry

4. Prof. N. R. Dhar, D.Sc., I.E.S., Professor of Chemistry, Allahabad University, Allahabad.
5. Prof. P. S. MacMahon, B.Sc., M.Sc., Professor of Chemistry, Lucknow University, Lucknow.

Zoology

6. Prof. D. R. Bhattacharya, D.Sc., Ph.D., Professor of Zoology, Allahabad University, Allahabad.
7. Prof. K. N. Bahl, D.Phil., D.Sc., Professor of Zoology, Lucknow University, Lucknow.

Botany

8. Prof. B. Sahni, D.Sc., Sc.D., F.L.S., F.A.S.B., Professor of Botany, Lucknow University, Lucknow.
9. Prof. K. C. Mehta, Ph.D., M.Sc., Professor of Botany, Agra College, Agra.

Mining and Geology

10. Prof. K. K. Mathur, B.Sc., A.R.S.M., Professor of Geology, Benares Hindu University, Benares.

Agriculture

11. Prof. C. Maya Das, M.A., B.Sc., I.A.S., Principal, Agricultural College, Cawnpore.
12. Dr. Sam Higginbottom, Principal, Agricultural Institute, Naini, E.I.R. (Allahabad).

LIST OF EXCHANGE JOURNALS

	Journals	Publishers
1.	The Bell System Technical Journal ...	The American Telephone and Telegraph Coy., New York (U. S. A.)
2.	Proceedings of the Imperial Academy of Japan.	The Imperial Academy, Ueno Park, Tokyo.
3.	Journal of the Franklin Institute ...	The Franklin Institute of the State of Pennsylvania, Philadelphia, Penna, (U. S. A.)
4.	Bell Telephone System (Technical Publications).	The Bell Laboratories, New York.
5.	Collected Researches of the National Physical Laboratory.	The National Physical Laboratory, Teddington, Middlesex, England.
6.	Report of the National Physical Laboratory.	Ditto.
7.	The Electrician	The Electrician, Bouverie House, London.
8.	Proceedings of the Cambridge Philosophical Society.	The Philosophical Society, Cambridge.
9.	Proceedings of the Royal Society of Edinburgh.	The Royal Society of Edinburgh, Edinburgh, England.
10.	Journal and Proceedings of the Asiatic Society of Bengal.	The Asiatic Society of Bengal, Calcutta.
11.	Proceedings of the Indian Association for the Cultivation of Science.	The Indian Association for Cultivation of Science, Calcutta.
12.	Scientific Notes of the India Meteorological Department.	The Director-General of Observatories, Poona 5.
13.	Memoirs of the India Meteorological Department.	Ditto
14.	Bulletin of the Madras Government Museum, Natural History Section.	The Connemara Public Library, Egmore.
15.	Bulletin of the Patna Science College Philosophical Society.	The Patna Science College Philosophical Society, Patna.
16.	Journal of the Indian Institute of Science	The Indian Institute of Science, Bangalore.
17.	Transactions of the Bose Research Institute.	The Bose Research Institute, Calcutta.
18.	Current Science	The Indian Institute of Science, Bangalore.
19.	Transactions of the Royal Society of Canada.	The Royal Society of Canada, Ottawa.
20.	Fifty Years Retrospect, Anniversary Volume.	Ditto
21.	Journal of the Royal Astronomical Society of Canada.	The Royal Astronomical Society of Canada, Toronto, Canada.

	Journals	Publishers
22.	Publications of the Dominion Astrophysical Observatory.	The Dominion Astrophysical Observatory, Victoria, Canada.
23.	Dominion of Canada Natural Research Council.	Ditto.
24.	Proceedings of the Royal Society of Victoria.	The Royal Society of Victoria, Melbourne, Australia.
25.	Journal and Proceedings of the Royal Society of New South Wales.	The Royal Society of New South Wales, Sydney, Australia.
26.	Transactions and Proceedings of the New Zealand Institute.	The New Zealand Institute, Wellington, New Zealand.
27.	Publications of the Alleghany Observatory.	The Alleghany Observatory of the University of Pittsburgh, Alleghany City (U.S.A.)
28.	Publications of the Observatory of the University of Michigan.	The Observatory Library, University of Michigan, Michigan (U. S. A.)
29.	Lick Observatory Bulletin	The Lick Observatory, University of California, Berkeley (U. S. A.)
30.	Proceedings of the American Academy of Arts and Sciences.	The American Academy of Arts and Sciences, Boston (U. S. A.)
31.	Memoirs of the American Academy of Arts and Sciences.	Ditto.
32.	Journal of Mathematics and Physics ...	The Massachusetts Institute of Technology, Cambridge, Mass. (U. S. A.)
33.	Proceedings of the National Academy of Sciences.	The National Academy of Sciences, Washington (U. S. A.)
34.	Proceedings of the Academy of Natural Sciences of Philadelphia.	The Academy of Natural Sciences, Philadelphia (U. S. A.)
35.	Year Book	Ditto.
36.	Astrophysical Journal	The Astrophysical Journal, University of Chicago, Chicago. Illinois (U. S. A.)
37.	Proceedings of the American Philosophical Society.	The American Philosophical Society, Philadelphia (U. S. A.)
38.	American Journal of Science ...	The American Journal of Science, New Haven (U. S. A.)
39.	Bureau of Standards, Journal of Research.	The Director, Deptt. of Commerce, Bureau of Standards, Washington (U. S. A.)
40.	Contributions from the Mount Wilson Observatory.	The Mount Wilson Observatory, Pasadena, California (U. S. A.)
41.	Communications (Solar Observatory)	Ditto.
42.	Annual Report of the Director of the Mount Wilson Observatory.	Ditto.
43.	Journal of Chemical Physics ...	The American Institute of Physics, New York, N. Y.
44.	Review of Scientific Instruments ...	Ditto.

	Journals	Publishers
45.	Transactions of the Astronomical Observatory of Yale University.	The Astronomical Observatory of Yale University, New Haven (U. S. A.)
46.	Publication in Zoology ...	... The University Library, Exchange Deptt., Berkeley, California (U. S. A.)
47.	The Philippine Journal of Science	... The Library, Bureau of Science, Manila P. I. (U. S. A.)
48.	Anzeiger (Mathematics and Science)	... Akademie der Wissenschaften, Vienna, Austria.
49.	Almanack	Ditto.
50.	Anzeiger (Philosophy and History) ...	Ditto.
51.	Bulletin de La Classe Des Sciences	... The Academie Royale de Belgique, Brüssels, Belgium.
52.	Annales De L'Institute Henri Poincare.	The Institut Henri Poincare, Paris (France).
53.	Mathematische Und Naturwissenschaftliche Berichte Ana Ungaru.	The Ungarische Akademie der Wissenschaft, Buda-Pest, Hungary.
54.	Sitzungsberichte Der Preussischen Akademie.	Preussischen Akademie der Wissenschaften, Berlin, Germany.
55.	Berichte Der Deutschen Chemischen Gesellschaft.	Deutsche Chemische Gesellschaft, Berlin, Germany.
56.	Nachrichten Von der Gesellschaft der Wissenschaften Zu Gottingen. Mathematisch-Physikalische Klasse.	Gesellschaft der Wissenschaften, Zu Göttingen, Germany.
57.	Geschaftliche Mitteilungen ...	Ditto.
58.	Mathematische Naturwissenschaftliche Klasse.	Bibliothekar, Heidelberger Akademie der Wissenschaften, Heidelberg, Germany.
59.	Berichte Der Mathematische Physischen Klasse.	Sachsische Akademie der Wissenschaften, Leipzig. C. I.
60.	Abhandlungen Der Mathematisch-Physischen Klasse.	Ditto.
61.	Sitzungsberichte der Mathematisch-Naturwissenschaftlichen.	Bayerische Akademie der Wissenschaften Zu Munchen, München, Germany.
62.	Communications from the Physical Laboratory, Leiden.	The Physical Laboratory, Leiden, Holland.
63.	Supplement, Communications from the Kamerlingh Onnes Laboratory.	Ditto.
64.	Rendiconti-Del Circolo Mathematico Di Palermo,	Palermo (Italy).
65.	National Research Council of Japan.	... The National Research Council of Japan, Tokyo, Japan.
66,	Japanese Journal of Mathematics ...	Ditto.
67,	Japanese Journal of Botany ...	Ditto.
68.	Japanese Journal of Physics ...	Ditto.
69.	Science Report of the Tohoku Imperial University.	The Director of the Library, Imperial University of Tohoku, Sendai, Japan.

	Journals	Publishers
70.	Proceedings of the Physico-Mathematical Society of Japan.	The Physico-Mathematical Society of Japan, Tokyo, Japan.
71.	Scientific Papers of the Institute of Physical and Chemical Research.	Komagome, Hongo, Tokyo.
72.	Journal of Science of the Hiroshima University (Zoology).	The Hiroshima University, Hiroshima, Japan.
73.	The Keijo Journal of Medicine ...	The Medical Faculty, Keijo Imperial University, Chosen, Japan.
74.	Bulletin De L'Academie Des Sciences Mathematiques at Naturelles.	The Akademie der Wissenschaft, Leningrad, Soviet-Russia.
75.	Jouranl Du Cycle De Physique et De Chemie.	Academie des Sciences D'Ukraine, Kyiv, Ukraine.
76.	Journal Du Cycle Mathematique ...	Ditto.
77.	Bulletin de La Classe des Sciences Physiques et Mathematiques.	Ditto.
78.	Memorias Do Instituto Oswaldo Cruz.	The Instituto Oswaldo Cruz, Brazil (U.S.A.)
79.	Physikalische Zeitschrift Der Sowjetunion.	Physical Journal of the Soviet Union, Kharkov, Chikovsakaya 16, Soviet-Russia.
80.	Geographical and Biological Studies of Anopheles Maculipennis in Sweden.	Kungliga Svenska Vetenskapsakademie, Stockholm, Sweden.
81.	Kungl. Fysiografiska Sällskapets Forhandlingar.	The Universitet, Lund, Sweden.
82.	Uppsala Universitets Arsskrift ...	Universitet, Uppsala, Sweden.
83.	Compte Rendu Des Seances De La Societe De Physique et D'Histoire Naturelle.	Societe D'Histoire Naturelle et de Physique, Geneva, Switzerland.
84.	Comptes Rendus Mensuels Des Seances De La Classe De Medecine.	Academie Polonaise Des Sciences et Des Lettres, Cracovie.
85.	Comptes Rendus Mensuels Des Seances De La Classe Sciences Mathematiques et Naturelles.	Ditto.
86.	Bulletin International De L'Academie Polonaise Des Sciences et Des Lettres Classe Des Sciences Mathematiques et Naturelles. Serie A.	Imprimerie De L'Universite, Cracovie.
87.	Ditto Ditto Serie B. 1.	Ditto.
88.	Ditto Ditto Serie B. 2.	Ditto.
89.	Bulletin International De L'Academie Polonaise Des Sciences et Des Lettres Classe De Medecine.	Ditto.
90.	Sprawozdania Z posiedzen Towarzystwa Naukowego Warszawskiego (History Literatury).	Societe des Sciences et des Lettres de Varsovie, Warsaw, Poland.

	Journals	Publishers
91.	Sprawozdania Z posiedzen Towarzystwa Naukowego Warszawskiego (Phisiology).	Societe des Sciences et des Lettres de Varsovie, Warsaw, Poland.
92.	Ditto (Matematycznofizycznych)	Ditto.
93.	Ditto (Biologicznych) ...	Ditto.
94.	Bureau of Fisheries (Document) ...	The Commissioner of Fisheries, Washington (U.S.A.)
95.	Science Bulletin	University of Kansas, Lawrence, Kansas (U.S.A.)
96.	Mathematisk-Fysiske Meddelelser ...	Kongelige Danske Videnskabernes Selskab, Copenhagen, Denmark.
97.	Biologiske Meddelelser.	Ditto.
98.	Transactions of the Royal Society of South Africa.	The Royal Society of South Africa, University of Cape-Town, Rondebosch, South Africa.
99.	Comptes-Rendus des Travaux Du Laboratoire Carlsberg.	The Carlsberg Laboratorium, Kobenhavn, Valby, Denmark.

JOURNAL SUBSCRIBED BY THE ACADEMY OF SCIENCES, U.P., DURING THE YEAR 1933.

PHYSICS

1.	Die Naturwissenschaften, 21 Jahrgang.	Hirschwaldsche Buchhandlung, Berlin, N.W.7.

LIST OF PAPERS READ BEFORE THE ACADEMY OF SCIENCES, U. P., DURING THE PERIOD APRIL, 1933, TO MARCH, 1934.

1. "Colour and Chemical Constitution. Auxochromic Effect of Hydroxyl and Amino Groups on Phthalophenone Nucleus," by Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
2. "Chemical Examination of the Roots of *Thevetia Neriifolia* (Juss)," by Narendranath Ghatak, M.Sc., and G. P. Pendae, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
3. "On the Trematode Parasites of a Rangoon Siluroid Fish-Clarias Batrachus (Linnaeus 1785)," by R. C. Chatterjee, M.Sc., Helminthological Institute, University of Rangoon, Rangoon.
4. "On the Absorption Spectra of the Oxides of Zinc and Cadmium," by P. K. Sen Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
5. "The Absorption Spectra of the Vapours of the Lower Chlorides of Elements of the Fifth Group of Periodic Table," by Hrishikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.
6. "A Note on the Vapour Pressure of Zinc Bromide," by M. S. Desai, M.Sc., Physics Deptt., Allahabad University, Allahabad.
7. "On the Absorption Spectra of Sulphides of Zinc and Mercury," by P. K. Sen Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
8. "On the Absorption Spectrum of Lead Monoxide and Lead Monosulphide," by R. S. Sharma, M.Sc., Physics Deptt., Allahabad University, Allahabad.
9. "On the Absorption Spectra of Hydrogen Peroxide," by R. S. Sharma, M.Sc., Physics Deptt., Allahabad University, Allahabad.
10. "On the Determination of the Values of γ for Air Saturated with Water Vapour at Various Temperatures," by Haji Gulam Mohammad, M.Sc., Physics, Deptt., Allahabad University, Allahabad.
11. "A Contribution to the Morphology of *Digera Arvensis*," by S. P. Naithani, M.Sc., Botany Deptt., Allahabad University, Allahabad.
12. "On New Trematodes of Frogs and Fishes of the United Provinces, India."
    Part I. New Distomes of the Family Hemiuridæ Luhe 1901 from North Indian Fishes and Frogs with a systemic discussion on the family Halipegidæ Poche 1925 and the Genera Vitellotrema Guberlet 1928 and Genarchopsis Ozaki 1925," by Har Dayal Srivastava, M.Sc., Zoology Department, Allahabad University, Allahabad.
13. "On the Absorption Spectra of Some Higher Sulphides," by P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
14. "On the Absorption Spectra of Some Saturated Halides," by R. S. Sharma, M.Sc., Physics Deptt., Allahabad University, Allahabad.
15. "On New Trematodes of Frogs and Fishes of the United Provinces, India."
    Part II. On Three New Trematodes of the Sub-family Pleurogenetinæ (family Lecithodendriidæ) from Rana Cyanophlyctis of Oudh, by Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

16. " Effect of Direction of Speaking and of Pitch in the Assam Council Chamber," by B. C. Ghosh, Prof. of Physics, Vidyasagar College, Calcutta, and Satyendranath Ray, M.Sc., Lecturer, Physics Deptt., Lucknow University, Lucknow.
17. " On the Trematodes of Frogs and Fishes of the United Provinces, India."

    Part III. On a New Genus Mehraorchis and two New Species of Pheurogenes (Pleurogenetinæ) with a systematic discussion and revision of the family Lecithodendridæ, by Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

18. "On a New Trematode with Anus belonging to the Genus Opegaster Ozaki 1928, from an Indian Eel Auguilla Bengaleusis," by K. R. Harshey, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
19. "On the Synonymy of Caphalogonimus Magnus Sinha with Cephalogoniums Gangeticus Pande and the account of a New Species of the Genus," by B. P. Pande, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
20. " Chemical Examination of the Seeds of *Abrus precatorius*, Linn."

    Part II. The colouring matter of the Seed-coat, by Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.

21. "A Note on the Optical Activity of the Alkaloidal Salts of Violuric Acid," by Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
22. " On Synge's Paper", by S. Subramanian, Lecturer in Mathematics, Annamala University, Annamalainagar P. O., South India.
23. "Absorption Spectra of Coloured Organic Salts of Violantin and Alloxantin" by Kedar Nath Gaind and Sikhibhusan Dutt, Chemistry Deptt., Allahabad University, Allahabad.
24. "Chemical Examination of the Leaves of the *Nyctanthes Arbortristis* Linn," by Jagraj Behari Lal and Sikhibhusan Dutt, Chemistry Deptt., Allahabad University, Allahabad.
25. "The Problem of the Stellar Structure, Part I," by D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.
26. " On the Absorption Spectra of the Halides of Elements of the Fifth Group," by Hrihsikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.
27. " On the Horizontal Comparison for the Location of Spectra of Heavy Elements," by S. C. Deb, M.Sc., Physics Deptt., Allahabad University, Allahabad.
28. "Cytoplasmic Inclusions in the Oogenisis of Passer Domesticus," by Murli Dhar Lal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
29. "Chemical Examination of the Bark of *Nerium Odorum*," by G. P. Pendse, M.Sc., and Sikhibhusan Dutt, Chemistry Deptt., Allahabad University, Allahabad.
30. "On the Absolute Summability (A) of Fourier Series," by M. L. Misra, Mathematics Department, Agra College, Agra.
31. " On the β-ray Activity of Radioactive Bodies," by M. N. Saha, F.R.S., and D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.
32. "Is the Neutron or the Proton the Fundamental Particle" ? by D. S. Kothari, Ph.D., Physics Deptt, Allahabad University, Allahabad.

33. "New Blood Flukes of the Family Spirorchisae Stunkard from Indian Fresh-Water Tortoises with Discussions on the Synonymy of Certain Genera and the Relationships of the Families of Blood-Flukes, Part II," by Dr. H. R. Mehra, Ph.D., Zoology Deptt., Allahabad University, Allahabad.

34. "Studies in the Viscosity Variations due to Chemical Reactions in Liquid Media," Part I, by Shridhar Sarvottam Joshi and Susarla Raju, Benares Hindu University, Benares.

35. "A Theorem Concerning the Zeros of the Laplace-Abel Integral," by Mr. S. P. Jain, M.Sc., Mathematics Deptt, Allahabad University, Allahabad.

36. "On the Absorption Spectrum of Nitrogen Monoxide in the Schumann Region," by Mr. P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.

37. "On an Interpretation of Absorption Spectra of Molecules," by Mr. P. K. Sen-Gupta, M.Sc., Allahabad University, Physics Deptt., Allahabad.

38. "On Amphistome Parasites of Sheep and Goat from Allahabad," by Mr. K R. Harshey, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

39. "On New Trematodes of Frogs and Fishes of the United Provinces, India."

Part IV. Occurence and the Seasonal Incidence of Infection of Certain Trematodes in the Above Hosts, by Mr. Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.

40. "Neutrons and Stellar Models," by Dr. D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.

41. "On Experiments in Acoustic Correction of the U. P. Legislative Council Chamber, Lucknow," by Mr. Satyendra Ray, M.Sc., Physics Deptt., Lucknow University, Lucknow.

42. "On the Absorption Spectra of Some Simple Salts of the Transition Elements. Contribution to the Theory of the Co-ordinative Linkage V^1, by Messrs. R. Samuel and S. Mujtaba Karim, Physics Deptt., Muslim University, Aligarh.

43. "Chemical Examination of the Seeds of *Abrus Precatorious*, Linn."

Part III. The Constitution of Abrine, by Mr. Narendranath Ghatak, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.

44. "Synthesis of Substituted Cinchoninic Acids through the Knœvwnagel Catalysts," by Mr. Madhusudanan Pandala, Chemistry Deptt., Andhra University, Waltair.

45. "The Application of Franck-Condon Principle to Continuous Absorption Spectra of Diatomic Molecules," by Mr. Hrishikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.

46. "On a Formula for $\pi_v(\chi)$, by Mr. S. M. Shah, M.A., Mathematics Deptt., Muslim University, Aligarh.

47. "A New View about the Bacteriophage and the Filtrable Viruses," by Mr. Ramesh S. M. Prabhu, M.Sc., Chemistry Deptt., Benares Hindu University, Benares.

48. "The Effects of Different Fresh Fruit Juice Media on Certain Strains of Heminthosporium," by Mr. Pestonji R. Bhagwagar, M.Sc., Botany Deptt., Allahabad University, Allahabad.

49. "The Quantum Analogue of a Theorem of Poison in Classical Dynamics," by Dr. D. S. Kothari, Ph.D., Physics Deptt., Allahabad University, Allahabad.

50. "The Origin of Combined Nitrogen in the Atmosphere. The Analysis of Tropical Rain and its Importance in Agriculture," by Mr. Atma Ram, M.Sc., Chemistry Deptt., Allahabad University, Allahabad.
51. "Notes on Bessel Functions," by Dr. S. C. Mitra, Ph.D, Mathematics Department, Dacca University, Dacca.
52. "On the Absorption Spectra of the Oxides of the Alkaline Earth Metals," by Mr. P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
53. "Cytoplasmic Inclusions in the Oogenesis of Muska Domestica," by Mr. Murli Dhar Lal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
54. "On the Summability of Fourier Series by Arithmetic Means," by Dr. B. N. Prasad, M. Sc., Ph. D., D.Sc., Mathematics Deptt, Allahabad University, Allahabad.
55. "Chemical Examination of the Seeds of *Plantago ovata* (Esabghol), by Messrs. G. P. Pendse and S. Dutt, Chemistry Deptt., Allahabad University, Allahabad.
56. "On a New Trematode from an Indian Fresh-water Fish," by Mr. B. P. Pande, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
57. "Nuclear Structure, γ-Ray Fission, and Expanding Universe," by Prof. A. C. Banerji, I.E.S., M.A., M.Sc., Professor of Mathematics, Allahabad University, Allahabad.
58. "Chemical Examination of Punar-Nava or *Boerhaavia Diffusa*," by Messrs. Radha Raman and S. Dutt., Chemistry Deptt, Allahabad University, Allahabad.
59. "On Two New Trematodes of the Genus Opegaster Ozaki with a Systamatic Discussion on the Families Opecoelidae Ozaki 1925 and Coitocaecidæ Ozaki 1928," by Mr. K. R. Harshey, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
60. "On the Theory of the Absorption of Poly Atomic Molecules," by Mr. M. S. Desai, M.Sc., Physics Deptt., Allahabad University, Allahabad.
61. "On the Linkage of Certain Oxides," by Drs. H. Lessheim and R. Samuel, Physics Deptt., Muslim University, Aligarh.
62. "On Changes on the Circular Orbit of a Particle when Disturbed by Small Tangential and Normal Impulse," by Mr. Avadh Behari Lal, M.Sc., Ramjas College, Delhi.
63. "Effect of Temperature on Borax Solutions in the Presence of Polyhydric Substances and Organic Acids," by Mr. S. M. Mehta, Royal Institute of Science, Bombay.
64. On a New Distome Ascocotyle Intermidius from the Indian Fishing Eagle, with remarks on the Genera Ascocotyle looss 1899 and Phagicola Faust 1920, (Family– Heterophyidæ). by Mr. Har Dayal Srivastava, M.Sc., Zoology Deptt., Allahabad University, Allahabad.
65. "Fluorescent Radiation from N_2O," by Mr. P. K. Sen-Gupta, M.Sc., Physics Deptt., Allahabad University, Allahabad.
66. "The Electronic States of Tin monochloride molecule and its Electron quantum numbers," by Mr. Hrishikesha Trivedi, M.Sc., Physics Deptt., Allahabad University, Allahabad.

Financial Statement—From 1st January, 1933, to 31st March, 1934

Receipts

	Rs.	a.	p.	Rs.	a.	p.
Opening balance on 1st Jaunary, 1933 ...				8	12	3
Bank balance on 1st January, 1933 ...				2,425	0	6
Government Grant (Non-recurring) ...				2,000	0	0
Allahabad University Grant for 1933-34 (Non-recurring) ...				500	0	0
Membership Fee:—						
Resident membership fee for 1931	60	0	0			
Resident membership fee for 1932	165	0	0			
Non-resident membership fee for 1932 ...	10	0	0			
Resident membership fee for 1933	540	0	0			
Non-resident membership fee for 1933 ...	180	0	0			
Resident membership fee for 1934	135	0	0			
Non-resident membership fee for 1934 ...	50	0	0			
Partpayment of subscription for 1935	5	0	0	1,145	0	0
Discount on outstation cheques of membership subscriptions ...				1	0	0
Total Rs. ...				6,079	12	9

Expenditure

	Rs.	a.	p.
Establishment ...	835	0	0
Contingency (Including printing, postage stamps, and stationery, etc.) ...	544	1	6
Journals for 1933 and 1934 ...	110	15	6
Printing of Bulletin Vol. 2, Nos. 2, 3, and 4, 1932-33 ...	1,402	9	6
Printing of Bulletin Vol. 3, Nos. 1 and 2, 1933 ...	705	3	6
Binding of journals ...	184	8	0
Furniture ...	42	0	0
Bank Charges on outstation cheques ...	5	12	0
Bank Balance:—			
Building Fund 66 0 0			
**Balance in hand Rs. 2,183 10 9	2,249	10	9
Total Rs. ...	6,079	12	9

	Rs.	as.	p.	Rs.	as.	p.
**Details of Balance in hand	2,183	10	9			
Establishment ...				5	0	0
Contingency ...				94	1	6
Journals ...				89	0	6
Printing of Bulletin 1932-33 ...				226	9	6
Printing of Bulletin 1933-34 ...				994	12	6
Binding of journals ...				12	0	0
Furniture ...				58	0	0
Building Fund ...				66	0	0
Balance in hand to meet expenses till the receipt of the next Government grant ...				704	2	9
				2,249	10	9

D. R. BHATTACHARYA, D.Sc., PH. D., F. Z. S.,
Hony. Treasurer,
The Academy of Sciences of the United Provinces of Agra and Oudh.

Message from His Excellency Sir W. Malcolm Hailey, The Patron of the Academy

This meeting of the Academy of Sciences receives additional importance from the proposal for an all-India Academy which was mooted at the recent Science Congress held at Bombay. The share taken by some of the members of the U. P. Academy of Sciences in that Congress shows the importance which the Academy has attained in the scientific world of India; every one will, I am sure, hope that it will receive increasing support and achieve continued success.

(Sd.) W. M. Hailey,
Governor,
United Provinces.

January 5, 1934.

Message from The Hon'ble Mr. J. P. Srivastava, The Minister of Education, U. P.

Thank you so much for your letter of the 3rd. I am so sorry it will not be possible for me to be present at the third annual meeting of the Academy of Sciences which will be held at Allahabad on Saturday, January 20, 1934, as I have another engagement for that day. I am, however, watching the progress of your Academy with great satisfaction. I am sure it will in time become the premier academy of its kind in India. From all accounts the Science Congress at Bombay has been a great success and I am proud of the part which the U. P. scientists played in it.

With kind regards,

Yours sincerely,
(Sd.) J. P. Srivastava,
Minister of Education,
United Provinces.

January 8, 1934.

PRESIDENT'S ADDRESS

ADDRESS OF THE PRESIDENT, PROFESSOR K. N. BAHL, AT THE ANNIVERSARY MEETING HELD ON JANUARY 20, 1934.

THE HON'BLE THE CHIEF JUSTICE, FELLOWS AND MEMBERS OF THE ACADEMY, LADIES AND GENTLEMEN,—My very first duty as President of the Academy is to accord on its behalf a hearty welcome to the Hon'ble Sir Shah Mohammad Sulaiman, Kt., M.A., LL D., the Chief Justice of the Allahabad High Court, who has kindly come over to preside at our anniversary meeting this afternoon. Although his main work lies in the administration of Law and Justice, he is known to take a keen interest in science. He has been a member of our Academy since its inception and I understand that he employs his spare time these days in the study of higher physics and in researches on theory of the universe, a subject on which he has promised to give us his own views this afternoon. We all hope that his association with us will help us in furthering the cause of scientific research in these provinces.

We are assembled to-day to celebrate so to speak, the third birthday of our Academy, which now enters the fourth year of its existence. In this country, almost notorious for its heavy infant-mortality, it is a matter for congratulation that the Academy, under the fostering care of Dr. M. N. Saha, its founder and first President and Professors Banerji and MacMahon, its energetic and painstaking secretaries,. has not only survived its period of infancy but is showing signs of developing into a healthy and promising child.

The honorary secretaries have placed before you an account of the progress made by the Academy during the year and I am sure, you will all agree, that with our limited resources, we have achieved a great measure of success. We wish to expand our activities in several directions but we lack the means for such expansion. And I have no doubt that as our work receives the appreciation it deserves, the Government and public at large will give us the financial support that we need.

I have selected "The Present Position of Darwinism" as the subject of my address, as the doctrine of Evolution forms one of the two most important generalizations of Biology and is also of application in other branches of human knowledge.

Present Position of Darwinism

The year 1858 forms a landmark in the history of scientific progress, nay even that of human thought, since it was in that year that Darwin and Wallace

formulated the great principle that Organic Evolution had occurred chiefly as a result of the action of *Natural Selection.* That evolution had taken place was known long before; Darwin even Darwin's grandfather Erasmus Darwin believed in the fact of evolution—in fact, some people have even traced the idea of evolution in the writings of ancient Greeks like Lucretius and Empedocles, but the great achievement of Charles Darwin was to give a satisfactory explanation, supported by copious evidence, of the *factors* which had brought about evolution. We must, therefore, at the very outset distinguish between the *fact* of evolution and the *theories* of evolution, for we must remember that " Darwin did not discover Evolution, as many people suppose, but he gave an account of the operating causes for the process of evolution."[1] That evolution has taken place is a fact supported by incontrovertible evidence and forms not only the accepted creed of all scientific men but has even permeated the thought and vocabulary of historians and political philosophers and even of theologians. But *how* evolution has taken place is the crucial question and Charles Darwin's great contribution was the answer to this question. Seventy-five years have elapsed since the publication of Darwin's classic, the " Origin of Species " and I shall attempt during the short time at my disposal to discuss how far the Darwinian hypothesis of Natural Selection has stood the test of critical biological thought.

Professor Huxley, who was a most ardent champion of Darwin's theory and called himself " Darwin's bull-dog, " summarises the Darwinian hypothesis in these words :—

" All *species* have been produced by the development of varieties from common stocks: by the conversion of these, first into *permanent races* and then into *new species*, by the process of *natural selection*, which process is essentially identical with that of artificial selection by which man has originated the races of domestic animals—the *struggle for existence* taking the place of man and exerting, in the rase of natural selection, that selective action which he performs in artificial selection."[2]

Darwin observed that variations occurred in nature; he postulated that these would be inherited from generation to generation and that in the multitude of individuals produced by every living species, all competing against each other for food and a place under the sun there will be a *struggle for existence* and consequently the *survival of the fittest.* The chief factors contributing to the process of evolution, according to Darwin, were variation, heredity and the struggle for existence leading to Natural Selection.

Let us begin our discussion by considering the nature, origin and inheritance of variations. Unfortunately our knowledge of this part of the

1 Wells, Huxley and Wells—*The Science of Life*, 1931.
2 Huxley's Collected Essays—Vol. II, p. 71.

subject was extremely limited in Darwin's time but the great impetus given by the Darwinian theory has resulted in a rich harvest of observed facts and experimental deductions, which have led to a correction and re-statement of this part of Darwin's theory. We are all familiar with the fact that parents and offspring, brothers and sisters are never quite alike; they always differ from each other and we call these differences *variations.* This variability occurs in every kind of character, shape, size and colour in simple cases of plants and animals, while in man "the most complex capacities, such as fertility, the power of resistance to disease, and intellectual ability are notoriously variable."[1] We can think of the enormous possibilities of variation, if we bear in mind the fact that variation may occur at any or all stages of life in the egg, the embryo, the young or the adult of an animal and of a plant.

But in spite of these variations, which are sometimes very striking, we have the great principle of heredity working all the time and it is this great conserving force that accounts for the countless resemblances in the whole organisation of one generation and the next. When the characters of a parent re-appear in the offspring, in popular language we say that the characters are inherited. In sexual reproduction, the male contributes the sperm and the female the egg and these two together go to make up the offspring. The offspring is, therefore, really a growth of the detached bits of its parents;[1] "it is a chip of the old block", in fact of two blocks since there are two parents. The great German zoologist Weismann put forward the idea that as it is part of a man and a woman which grows into their children—it is really their own living substance which is handed on from generation to generation and he used the term *germ-plasm* for this immortal bit of the organism to distinguish it from the *soma* or the remainder of the body which is mortal. The *soma* lives and dies but the germ-plasm goes on indefinitely. If life had a single origin, all the living organisms would be traced to one stock—they would all be the twigs of the original tree or trunk of the germ-plasm. This conception of Weismann is called the theory of the *continuity of germ-plasm.* We can thus think of an actual material continuity between our own germ-plasm and that of the original living organism that first appeared on the surface of this earth.

The question naturally arises as to how it is that with this continuity of germ-plasm, we have the wonderful variety and diversity of form that we find amongst organisms. We must have variation in the germ-plasm in order to have any variation amongst organisms at all. The older naturalists assumed that the use and disuse of organs and the external environment generally induced changes in the organisms and that these changes were

[1] Goodrich—*Living Organisms,* 1924.

transmitted and reappeared in the progeny. This point of view was specifically put forward long before Darwin by the French naturalist Lamarck who gave as example the case of the long neck of the giraffe; according to him the ancestral giraffe stretched its neck to reach the leaves of the higher branches of trees, the offspring kept up this useful habit which was inherited, so that by generations of continuous stretching of the neck, the species has acquired this permanent character of a long neck. Lamarck would seem to say, "Master what you can of Mathematics and your child will calculate with greater ease."[1] Darwin himself was hard put to explain the origin of variations and for want of an adequate explanation, he accepted that variations were the effects of differences in environment but he was not quite comfortable about the matter since he wrote to Huxley, "If, as I must think, external conditions produce little effect, what the devil determines each particular variation."[2] Unfortunately Lamarck's theory of the inheritance of acquired characters has not been able to stand the test of critical examination and has been largely overthrown. Weismann tested it experimentally by cutting off the tails of mice, generation after generation, but the young mice continued to grow tails. Similarly the effects of use and disuse, *e.g.*, the enlargement of muscles in the arm of a blacksmith or even the results of education have not been proved to be inherited as such from one generation to the next. The fact is, as Weismann postulated, that the change induced in the *soma* or body cannot be transmitted to the offspring; for any hereditary change, the *germ-plasm* must be modified. These conclusions of Weismann form a most important contribution to the science of evolution since the time of Darwin.

Another valuable point of view first advocated by Professor Sedgwick and developed later by Sir Archdall Reid and other is that each character of an organism is the product both of factors of inheritance in the germ-plasm and of environment and can only be reproduced when both are present. Not only every part of an organism but all its habits and activities are the results of the combined action of factors of inheritance and environment. We can distinguish between the effect of a factor of germ-plasm and that of the environment by a simple example. There is no more fundamental character of a green plant than its greenness. Yet if we grow the seed of the greenest plant in a dark chamber, the plant will not be green. The environmental stimulus of light is absent. We may say that "the green character is not transmitted, it is not inherited."[3] But what is really inherited is the capacity to become green and this capacity is present in the factors of the

[1] Wells, Huxley and Wells—*The Science of Life*, 1931.

[2] Haldane—*The Causes of Evolution*.

[3] Goodrich—*Living Organisms*, 1924.

germ-plasm, as can be seen at once by bringing the pale seedling into light, when it will turn green in a day or two. The presence of iron in the soil is another necessary condition for the development of green colour. The plant may have the necessary capacity and the brightest of sun-light, but lack of iron will not give the green colour. Similarly, the common belief that tuberculosis is transmitted from parent to offspring is fallacious. Tubercle bacilli are present almost everywhere in crowded streets and dirty surroundings but if your constitution is strong and your lungs healthy, you will not develop tuberculosis. What the offspring of a tuberculous patient will inherit will be a weak constitution and lungs susceptible to disease and if by adequate nourishment and other means, the constitution is made strong and the children are kept in clean and healthy surroundings, they need have no fear of getting tuberculosis at all. An organism, therefore, is the result of the interplay of the factors of inheritance and the conditions of the environment. In order to have a healthy plant, you need not only good seed, but also a good well-manured soil.

From the point of view of variations, therefore, we must distinguish between variations produced by a germinal change in a constant environment and variations which are induced by a change in environment only while the germinal constitution continues the same. The former are called *mutations* and the latter *modifications*. These variations cannot be distinguished by a mere inspection but only by systematic observation and experiment. The analysis of variations by these means has been carried out only during the last 30 years and has yielded very interesting and useful results which constitute another notable advance in our knowledge of the process of evolution.

The impetus for this analysis of variations was provided by the re-discovery of Mendel's monumentel work in 1900. Working in the seclusion of the cloister garden at Brunn, this Austrian monk carried out experiments for eight years on the common pea plant and published his work in 1865, only six years after the publication of Darwin's "Origin of Species." For 35 years, his work was neglected but since 1900 it has become very famous. In simple terms, Mendelism postulates that it is the gametes, the egg and the sperm in the case of animals and the polien-grain and the ovule in the case of plants that carry the factors which are capable of giving rise to the characters of animal and plants. These factors are now called *genes*. Further, a given gamete can carry one and only one of any alternative pair of characters. In the pea plant, for example, it can carry either tallness or dwarfness but not both. In biological language, we describe this as Mendel's law of the *purity of the gametes*. If a tall pea plant has been crossed with a dwarf and the hybrids grow and flower, there will be a segregation of the characters tallness and dwarfness at the time of the formation of the gametes. With this simple principle added

to the law of dominance as a guide, biologists have built up a whole science of Heredity or Genetics and have succeeded wonderfully in extending the scope of Mendel's work and its applications. Through a knowledge of Mendel's law, biologists have been able to raise the desired breeds of animals and plants; they have been able to explain the mechanism of the determination of sex and the transmission of several diseases in man; in fact, Mendelism has provided the key to the working mechanism of heredity. We in India owe a deep debt of gratitude to Mendel whose discovery led Sir Rowland Biffen to raise a rust-proof variety of wheat at Cambridge and this in turn led the Howards at Pusa to raise the famous Pusa varieties of wheat which are gradually replacing the old indigenous varieties and which account for the increasing prosperity of the wheat-growing areas in the United Provinces and the Punjab. Similarly breeds of cow with a high rate of milk-yield have been raised and also breeds of poultry with a high rate of egg-production.

The thrilling problem of the determination of sex attracted a number of distinguished workers who have succeeded in elucidating the mechanism of sex-heredity. Doncaster and Raynor in England were the first to discover the phenomenon of sex-linked inheritance; Goldschmidt in Germany has worked out the mechanism of the so-called "intersexes," but the most outstanding contribution has been made by Morgan and his colleagues in America, who have carried the analysis a stage further by correlating sex-heredity with the differences in the chromosome constitution of the cells of the two sexes. In recognition of this work of his school, Thomas Hunt Morgan has only recently been awarded the Nobel Prize. A start was made by proving that sex is a definite, heritable character, exactly comparable to the tallness and dwarfness of the pea-plant or the black and blue colour of the eye in man. Cases of sex-linked inheritance were next worked out in moths and poultry, and finally in the fruit-fly *Drosophila*, the determination of sex was definitely proved to belong to one particular chromosome, the sex-chromosome. In man, two kinds of sperms—male-determining and female-determining—have been demonstrated, so that we now know exactly *how* sex is actually determined. Unfortunately we cannot yet *control* sex, although vigorous attempts are being made to discover a means of separating the male-producing from the female-producing sperms in order to paralyse one set or the other as desired. These attempts have not been successful thus far, but it may be not long before some one solves the problem and we may then have the means ready to decide the sex of our children and satisfy many people who are desperately anxious to have a child of a certain sex.

Several human defects and diseases have been shown to follow the line of simple Mendelian inheritance. Presenile cataract of the eye, night-blindness and colour blindness have been proved to follow Mendelin inheritance;

so does *haemophilia*, a disease which afflicted the late Tsar's ill-fated son and which brought the Tsarina, as the story goes, under the influence of Rasputin. Specially poignant to the Tsarina must have been the knowledge that this disease is transmitted by the mother herself to her sons alone. As our knowledge of heredity has increased, we have discovered out that certain diseases cannot be rooted out; they inevitably pass on from one generation to the next. Inherited feeble mindedness is one such disease and one can understand why Germany has made a law for compulsory sterilisation of the feeble minded and why there is a movement in England as well for a similar law although on a voluntary basis.

From the point of view of Darwinian Evolution, however, the chief contribution of Mendelism is to establish that heritable variation has a definite basis in the gamete and that it arises by a sudden step it is discontinuous, because it is based upon the presence or absence of some definite factor or factors in the gametes from which it sprang. Darwin's view was that a character was developed by the gradual accumulation of minute variations occurring at random and he emphasised this point by using a Latin phrase "*Natura nihil facit per saltum*" *i.e.*, Nature does not work by jumps. Bateson in 1895 pointed out that species do not pass gradually from one to the other but the differences between them are sharp and definite "Why don't we get intermediates of all sorts more frequently in nature?" he asked, "if specific differences arise by an accumulation of minute and almost imperceptible differences." De Vries, on a prolonged study of the evening primrose *Oenothera* concluded that new varieties arose from older ones by sudden sharp steps or "mutations." Finally all the work on Mendelian lines has convinced biologists that Darwin's idea of the summation or accumulation of minute random variations must be abandoned and that we must regard variations appearing as "sports" or mutations and their origin as due to the addition or subtraction of factors in the gametes. Once formed, natural selection decides whether these new characters will persist or not. It is these mutations, therefore, that furnish the raw materials of evolution. But the explanation is still incomplete. We have localised problem but have not succeeded in solving it yet. The origin of the new mutations has yet to be explained satisfactorily. Some biologists believe that in the course of the maturation of the germ-cells, which is a very important phase in their development, there is a re-shuffling of the cards in the pack of factors of hereditary characters; others attach great importance to fertilization or crossing and this is not surprising when we remember that two very complex systems, usually of diverse origin, become in the act of fertilization a unity that develops in most cases into a harmonious life. In fact, there is ample experimental evidence to show that novelties are induced by crossing but unfortunately

this factor alone does not seem sufficient to account for the origin of all new specific variations.

I now pass on to the essential part of the Darwinian hypothesis, *i.e.*, the action of *natural selection*, in respect of which Darwinism has emerged unscathed even from a most exacting scrutiny. In his "Origin of Species," Darwin emphasised in the first place the fact that living organisms multiply in geometrical progression and thus constantly tend to press upon their means of subsistence, this idea being probably due to Malthus. We know from observation that the daily life of animals and even of man is primarily a hunt for food; in fact, according to a French writer, life can be summed up in the conjugation of the verb "to eat"—its pleasant active voice (except for the dyspeptic) and its awful correlative, the passive[1]. In general, the total population of any region of the earth is a direct reflection of the balance between "I eat, you eat, he eats, etc." and the passive—"I am eaten, you are eaten and he is eaten, etc."[1]. Darwin took the example of the elephant as the slowest breeder amongst animals and estimated that if all the progeny of a single pair survived, in 500 years we shall have 15 million elephants. Yet the average number remains more or less steady, which means that only two young ones of a pair survive the rest die out. In this process it is the better equipped that survive and the worse-equipped die. The struggle for existence acts like a sieve; it selects those that possess advantageous variations and eliminates the useless and the undesirable.

That natural selection is at work all the time has now been proved experimentally, although such experimental evidence was lacking in Darwin's time. In 1904, di Cesnola tied up 20 green and 45 brown specimens of *Mantis* in green grass and found that after 19 days, 35 browns had been eaten by birds but none of the greens. Similarly when he tied brown and green *Mantises* on brown grass, the greens were all eaten while all the browns remained alive.[2] Here was natural selection at work through the agency of birds. Recently in 1920, Harrison has brought forward evidence to show natural selection at work among the moths of the species *Oporabia autumnata* in a mixed wood of pine and birch in Yorkshire, and several other workers have adduced similar evidence.

I shall not take your time in enlarging any further on this – the most important aspect of Darwinism, nor shall I deal, as I would very much like to, if I had the time with "isolation" as a maker of species, nor with the interesting question of Orthogenesis or straight-line evolution.

To sum up, we must conceive of a living organism as a complex of a large number of characters subject to mutations in succeeding generations.

[1] Dakin—*Introduction to Biology.*

[2] Haldance—*Causes of Evolution*,

These mutations are called forth by a change in the germ-plasm and are inherited. "But since many differences of an advantageous or disadvantageous sort exist and are inherited, the struggle for existence or natural selection acts on a species like a filter or a sieve. It selects types of success and failure, sets a premium on advantageous variations and continually removes a large majority of the disadvantageous ones, so that the average of the species moves in the advantageous direction."[1] Darwinism thus stands vindicated to-day; it has emerged almost unchanged after a most critical examination extending over three quarters of a century and serves to account for the process of Evolution with a cogency and a completeness unequalled by any other explanation.

[1] Wells, Huxley and Wells—*The Science of Life*, 1931.

ADDRESS BY THE HON'BLE SIR SHAH MOHAMMAD SULAIMAN, Kt., M.A., LL.D., CHIEF JUSTICE, HIGH COURT, ALLAHABAD.

LADIES AND GENTLEMEN,

It is a great honour for me to preside at this assembly of learned scientists and I certainly feel that it is rather audacious on my part to attempt to discuss before you any scientific subject, in which I have not the time to specialise. But I can feel no hesitation in referring to the remarkable progress which the Academy of Sciences has made during the short period that it has been in existence.

As Prof. Banerji, the Hony. General Secretary, has shown in his Report for the last year, the number of members on the roll of the Academy has been steadily increasing. If this progress is maintained, as it is sure to be, the Academy will be a fully representative body of scientists engaged in scientific study or teaching work or in research.

The Bulletin issued by the Academy has contained valuable papers of a high order on various scientific subjects, which have been very much appreciated. The authors of the articles deserve to be congratulated on the valuable contributions made to the advancement of scientific knowledge. That the value of the Bulletin is fully recognised abroad is amply evidenced by the fact that it is already receiving in exchange about one hundred scientific Journals from almost all parts of the world. The Bulletin in this way is playing an important part and helping to build up a library of up-to-date scientific literature.

The success achieved so far has been due mainly to the inspiration and encouragement received from His Excellency Sir Malcolm Hailey, the Patron of the Academy, as well as to the enthusiasm and devotion of its Presidents, Secretaries and other office-bearers, who are sincerely endeavouring to raise it to the status of an All-India Academy of Sciences.

The branches of Science have now become so numerous and the accumulation of knowledge in each branch so vast, that even a whole-time scientist can never hope to master them. Much less can an amature like myself feel competent enough to deal with the engrossing problems of all the branches of the Science. I confess, I know very little about Biology. All of us have some perfunctory knowledge about evolution, but few of us know the details of thrilling problems like the determination of sex. But we are all indebted to Prof. Bahl for his very lucid and clear exposition of Darwinism. For the teeming millions who know nothing about birth control, it is certainly a happy news to be told that offsprings of tuberculous patients do not inherit the

disease. Physics is the only subject of which I have managed to keep up some knowledge in a very limited way. I have, therefore, to confine my address to one aspect of Modern Physics, which of all others is the most mysterious and an apparently unintelligible phenomenon. The present conception of light as the origin of all the modern troubles has led to the propounding of most amazing theories and apparently contradictory assumptions. The answers offered for some of the perplexing questions concerning the nature of light are designed to take us deep into the realm of unreality, where we not only lose all mental picture of it, but it becomes so illusory as to be entirely beyond our comprehension. Eminent scientists have to admit that the present theories have landed us in a *cul de sac* and there seems to be no way out of it without retracing our steps.

I have ventured to prepare my written address in the hope that a destructive criticism from an outside source, based upon a collection of the existing anomalies and contradictions, and if I may be permitted to say so, even absurdities in the modern ideas, may not only expose the utter inadequacy of the present day accepted views, but may perhaps pave the way for a new constructive theory, that will get over the existing difficulties.

As copies of my printed address are available to you all, I am relieved of the necessity of reading the whole of it. I shall accordingly content myself with reading only portions of it here and there.

THE ADDRESS

It is a great privilege to me to be invited to preside at this session of the Academy of Sciences. I have accepted the honour with considerable diffidence, because it is somewhat presumptuous on the part of any outsider to intrude upon the consecrated precincts of Science and be bold enough to make a critical survey of the development of any of its branches. One, who is absorbed in other engrossing pre-occupations and can hardly spare time for a devoted pursuit of scientific knowledge, much less its experimental side, would naturally hesitate to attempt to examine the very foundations upon which some of the modern conceptions of the structure of the Universe are based. But liberty of thought is not the sole monopoly of great scholars and eminent scientists only, and the portals of even a sacred cloister have, on occasions, been allowed to be invaded by an outside observer. I may, therefore, be excused for a somewhat similar encroachment.

In spite of the vast accumulations of the store of scientific literature, it must be admitted that human knowledge is still very much in its infancy. Our abysmal ignorance is at once revealed when we endeavour even to comprehend the vastness of the Nature around us. When we try to appreciate that the Sun, whose size is more than one million three hundred thousand times that of the Earth we inhabit, might well have existed for the last eight

million million years, that the Earth itself must have existed for the last two thousand million years and may yet last for a much longer period, that life on this Earth might well have existed for three hundred million years, while man could have hardly lived on it for more than three hundred thousand years, it becomes apparent that the period of a few thousand years during which the stock of human knowledge has been growing is but a negligible infinitesimal fraction of time, a mere drop in the fathomless ocean.

The great Sun is only a tiny speck in the vast Universe. Light travelling at the stupendous rate of 186,000 miles per second takes about eight minutes to come to the Earth from the Sun. But the light from even the nearest Stars takes not seconds, minutes, hours, days and months, but four years and a quarter, or more, to reach the Earth. There are some four hundred thousand million Stars, including our Sun, which form one Galactic system, bounded by the Milky Way, across which light at that terrific speed would take two hundred and twenty thousand years to travel from one end to the other. Outside this huge Galactic system there are still more distant nebulæ, some two millions of which are now visible in the great 100-inch telescope at Mt. Wilson. The most distant of these nebulæ revealed at present are so far away that light at the rate of one hundred and eighty six thousand miles per second would take one hundred and forty million years to come to the Earth. What further depths of space would be revealed if a 200-inch telescope now in contemplation is constructed! But even this will admit only about a million times as much light as an unaided eye. And it is at present beyond our comprehension what still bigger Supergalaxies and still greater Metagalaxies would not be revealed, when astronomical instruments improve further, and in what inconceivably gigantic dimensions Universes surrounding Universes would not be disclosed. In face of these staggering figures, the utter insignificance of Man's place in this vast Universe can be readily realised. This Outer World represents but one side of the range of human vision.

On the other side, we have the minutest particles constituting worlds within worlds. Matter has been found to consist of molecules of a hundred-millionth inch in diameter, so minute that a pint of water would contain twenty million, million, million, million molecules, the weight of each being of the dimension a million million million millionth fraction of an ounce. Each such molecule consists of two or more atoms. Some two hundred and fifty varieties of atoms (including isotopes) of smaller sizes have been discovered, which account for ninety different elements. In its turn, every atom consists of electrons and a nucleus. An electron has a radius of 5 million millionth part of a centimeter. It revolves round its nucleus several thousand million million times every second. The nucleus, though in fact much heavier, is so condensed that it is even smaller in size than an electron. But all these are heavier bodies as compared to light particles, if they at all exist.

To imagine the speed at which these may be vibrating it may be mentioned that an electron vibrates at the rate of 124 million million million complete oscillations per second. Protons constituting the nuclii may be vibrating at even a greater speed of 229 thousand million million million oscillations per second. As Science is making tremendous strides, it is impossible to hazard even a guess what further inner-most depths of the Inner World will not be disclosed very soon.

Standing somewhere perhaps mid-way between the Unknowns on the two sides, Man's power of observation is strictly limited between apparently very narrow limits. As scientific knowledge progresses, these limits will no doubt be extended further and further on both sides, and yet our knowledge will ever remain very meagre and scanty. We can only have mere glimpses of the vast expanse of Nature, and our theories are but conjectures and speculations as to the ultimate Reality. Yet in spite of all our hopeless imperfections, advance is being made rapidly in increasing geometrical progression. The last decade has brought about a tremendous revolution in scientific thought. The conception of the Universe as a great machine working in an ordered way has completely collapsed. Nature is now regarded as being capricious and arbitrary, and her processes as sudden jumps, and uncertain jerks, without following any methodical Law of Causation. The Law of Causation has been dethroned from the honourable position which it had previously occupied, and its prominent place has been taken by a new Law of Indeterminacy which inexorably lays down not only a subjective, but even an objective Uncertainty. Everything in the Universe is now believed to be comprised of mere imaginary waves of Probability and Chance, so that nothing substantial, tangible or real exists in it.

I propose to scrutinise the very basis upon which Modern Science has built this huge, but imaginary structure, by considering first the successive steps which have driven us into such a desperate and helpless position. The principal origin of the trouble lies in the conception of light, to which alone I shall confine myself. I may be permitted to begin with a historical background, showing how and why various theories have had to be abandoned, giving place to present day conceptions. As this assembly of learned men and women consist of Physicists as well as non-Physicists, I fear I cannot make myself intelligible, without a somewhat detailed survey.

It is not too much to presume that when the human mind became sufficiently developed, one of the very first wonders which would have struck it must have been the mystery of vision. Eyesight is our dearest possession. Half of the happiness of life would be gone if we lost our vision, and missed all the glories and beauties that surround us. Our very comprehension of the magnificent design of the Great Maker would be lamentably incomplete if we had no means of observing the multifarious manifestations of Nature. One

can imagine the ancient philosophers asking themselves some such questions as these: How are bodies visible though they are at a distance? How do we see things, which we cannot touch? How are various objects perceptible at all? How is there a connection between the eye which sees and the object seen? But no serious endeavour was made to answer them for ages.

The ancient thinkers believed in a multiplicity of divinities, and felt no difficulty in attributing every observed phenomenon to a direct intervention of the gods. There was a Sun god who was responsible for sending out all the light and heat from the Sun to the Earth, and there was a god of fire who gave us fire from which heat and light were produced on the Earth itself. Another god caused lightning and thunder. The ancient philosophers did not feel themselves called upon to investigate the origin of heat or light. They took it for granted that such phenomena were mere creations of divine beings. It is therefore not surprising that the great minds of the early Assyrian, Egyptian and Aryan philosophers were not concerned with the mysterious phenomenon of vision, for in it they hardly saw any mystery at all. The early Persians or Iranians in the same way regarded fire as a divine manifestation. When Zoroastrians worshipped the sacred fire, their learned men could not be expected to pry into the genesis of what to them was nothing short of a symbolical embodiment of the divine being. One can safely presume that up to the time of the religious leader Zoroaster زردشت (1000 B. C) there was no occasion to bestow any serious thought on the physical problem of light.

So far as available historical records show the credit of making the first attempt to tackle this question must go to the early Greek philosophers. In spite of their beliefs in super-human agencies they endeavoured to evolve some intelligible theories to explain the mystery of vision. The name of the great philosopher Pythagoras فیثا غورس (572-497 B. C.) stands out in eminence for being the first to put forward a rational hypothesis. In his conception of the Universe as consisting of spheres moving in perfect harmony round the earth as centre, producing beautiful tones of music, he regarded all objects as an integral part of the harmonious whole. He conceived that light consisted of small particles that were thrown out from the object seen and entered the eye and this caused vision. According to him the particles were continually projected into the pupil of the eye, and thereby enabled men to see things. He was undoubtedly the first propounder of what later on came to be described as the Corpuscular Theory of Light.

Some 100 years after, the great Italian philosopher Empedocles انبیذ قلیس (444 B C.), who belonged to the Pythagorean school, conceived the world as consisting of four fundamental elements, earth, water, air and fire عناصر اربعہ. He rightly regarded all luminous bodies as the seat of fire; but his conception of light was that vision was effected by something emitting from the eye itself which after meeting something else emanating from the object excited the

sense of sight. This curious view could not be completely exploded till the advent of photography in recent times which dispensed with the eye for the purposes of vision. About the same time Philolus فلاؤس (430 B. C.) considered that all the heavenly bodies revolved about a "central fire" which, however, was not visible to the inhabitants of earth, as the earth's face was always turned away from it. All the same it was the source of all heat. Anaxagoras انكسا غورس (450 B. C.) reverted to the Pythagorean idea and regarded the Sun as a hot stone, from which light was emitted and believed that the moon shone by reflected light.

Another century later, Plato فلاطون (350 B. C.) the famous disciple of Socrates سقراطا (470-399 B. C.), but greater than his master, founded a new school of philosophy. Quite in keeping with his natural religious tendencies, his philosophic mind combined the Zoroastrean conception of the divine element in fire, the Pythagorean idea of emission from objects, the Empedoclian assumption of emission from the eye, and added something of his own. His idea of vision was that it was caused by three distinct elements (1) divine fire emerging from the eye (2) light of the Sun following on an object and (3) emanations from the object seen. A visual stream of divine fire or rays emitted by the eye united with the light of the sun, and together combined with the emanation from the object, and in that way completed the act of vision.

His greatest disciple Aristotle ارسطا طاليس (340 B. C.) for the first time put forward an entirely original hypothesis that light is not at all a material emission from a source, nor any emanation from the eye, but is a mere property of or due to an action of the medium between the eye and the object. This was without doubt the first known origin of the modern Wave Theory of light.

The notion of Euclid اقليد س (340 B. C.) was that vision was caused by the interaction of something given out from the eye with something given out by the luminous or illuminated body. He tried to refute the Pythagorean emission theory. In the time of Ptolemy بطليموس (70-147 A. D.) all these rival theories continued, but he was inclined to the Pythagorean idea and explained reflection and even refraction of light on that supposition. Epicurus ابيقورس and Lucretius لقر اطوس were supporters of what has been termed the quasi-tentacular theory, and imagined that we perceive objects by means of light in much the same way as we feel things by means of a stick.

Curiously enough this strange hypothesis survived for many centuries, until ultimately Alhazen محمد ابن الحسن ابن الهيثم (died in 1038 A. D.) an Arab scientist of Basra, definitely discarded the idea of any emission from the eye and laid down a mathematical theory of light based on the hypothesis that the cause of vision proceeds from the object itself. His conception was that it is not a single ray of light, as had been assumed up to his time, but a cone of rays that proceeds from the object to the eye. On this theory he explained

reflection and refraction of light. He also examined the anatomy of the eye and showed how with two eyes we see only one object, and also explained many optical illusions. He showed why there was an apparent increase in the diameter of heavenly bodies near the horizon, how distances can be judged by the different vertical angles of the cone of light. This was a great advance in the conception of light and his theory remained accepted in Europe for more than 500 years after him. The Latin translation of his work on Optics was available to Vitellio and Roger Bacon in the thirteenth century.

Even great scientists like Copernicus (1473-1543), Galileo (1564-1642) and Kepler (1571-1630), to whom modern Science owes so much, did not improve upon Alhazen's conception. But Descartes (1638) reverted to the Aristotelian idea of an action of the medium which was called æther. Great strides were made in scientific discoveries, and Romer (1667) established from observations of the eclipses of Jupiters' Satellites that propagation of light had a definite velocity which he measured. Descartes thought that light was due to pressure transmitted instantaneously through a perfectly elastic medium which filled all space, and that colour was the result of some sort of a rotatory motion of the particles of the æther. But it was Charles Huygens (1629-1695) who in 1678 propounded an elaborate wave theory, under which light was due to a mere wave motion in a medium called æther. He gave a complete theory in a definite form, showed how reflection and refraction take place, and accounted for even double refraction. He is unanimously regarded as the true founder of the Wave Theory of light.

Newton (1642-1727), however, remained unconvinced and adhered to the Corpuscular Theory of light, because Huygens' Wave Theory failed to explain satisfactorily the rectilinear propagation of light or the casting of shadows. But simultaneous reflection and refraction at a surface was an apparent difficulty in the way of the Corpuscular Theory. So Newton attributed to the corpuscles "periodic phases or fits of easy reflection and easy transmission," so that sometimes they are in a condition to be reflected and sometimes in a condition to be refracted. He had to assume the existence of the æther, and further that forces of repulsion in the case of reflection and of attraction in the case of refraction come into play. His assumption was that velocity when resolved parallel to surface remained unchanged, but when resolved along the normal was altered. This last assumption resulted in the necessary conclusion that the velocity of light in denser (more refracting) medium must be greater than in rarer (less refracting) one.

The Wave Theory did not replace the Corpuscular Theory till Young (1802) explained how there could be interference on Huygens' Wave Theory, which was not possible on Newton's Corpuscular Theory, and Fresnel (1820) announced how polarisation of light could be explained only on the Wave Theory by assuming that the vibrations in the æther are transverse and not

longitudinal. Both Young and Fresnel demonstrated how an undisturbed succession of waves of sufficient width would move as a beam, spreading out like a shower of particles, without appreciably bending sideways. In this way interference, diffraction and polarisation of light were also satisfactorily explained, for which Newton's Corpuscular Theory was wholly inadequate.

The essential difference between the Corpuscular and the Wave theories is well known. According to the former theory a luminous body continually emits very small corpuscles or particles in all directions. These, when projected from it, bodily travel, like an arrow or bullet, through space with the velocity of light. There is thus a bodily motion of these small corpuscles from one point to another in space, and they carry with them their kinetic energy or energy of motion. According to the latter theory there is an all-pervading medium called æther, the vibrations of which are light. No particle of the æther travels along, but there is a mere relative displacement or disturbance, which is passed on through space. The particles of the æther merely oscillate transversely, and are not at all translated forward longitudinally. The wave propagation resembles the propagation of vibration, when one end of a long steel rod is hit sideways and a vibration is felt at the other end, although in point of fact no particle of the steel rod has travelled from one end to the other.

The Wave Theory of light came to be accepted as a natural theory, because scientists were familiar with the propagation of sound waves and also water waves. Light could be easily imagined to be some sort of a wave, provided an invisible medium like the supposed æther could be invented. By 1850 Foucault and Fizeau established experimentally that the velocity of light in water was less and not greater than that in air. This was a death blow to Newton's Corpuscular Theory, and no option was apparently left but to fall back on the Wave Theory.

But the Wave Theory brought with it its own difficulties:—

(1) The existence of an æther was an indispensable condition, but the nature and properties of the imaginary æther were not easy to formulate. Different æthers had to be postulated for different purposes, as different properties were required to explain different phenomena. The only variety of æther that survived was the *luminous æther* as conceived by Huygens. (2) The first problem was whether this æther should be assumed to be a gas, a fluid or a *solid*. Air and fluids were not found to transmit transverse vibrations, as they offer practically no resistance to distortion. So scientists were compelled to assume that the æther was a *solid* body stretching throughout space. (3) But longitudinal vibrations were not observed at all, as no optical phenomenon indicated any vibrations normal to the wave front. Accordingly there was no option but to assume that (a) either the longitudinal vibration was

infinite, in which case the æther would be absolutely *incompressible*, or (b) that it was nil or zero, in which case the æther would be *contractile*, *i.e.*, offering a negative resistance to compression. (4) But as no displacement whatever can take place if the æther were rigid, it had to be assumed that the æther was an *elastic* solid. But it cannot be elastic without having *torsional rigidity*, *i.e.*, resistance to change of shape. (5) But as there can be no direction fixed in space, the æther must be *uniform* in all directions, and so it must be capable of all possible vibrations; and yet it had *only transverse* and not longitudinal vibrations. If there was a perfect uniformity of the æther inside a crystal, it would not adequately explain polarisation and double refraction. (6) It was found that light had a finite velocity. Mathematically the velocity of a wave propagation in an elastic solid is proportional to the square root of its elasticity divided by its density. So the æther must have (a) either *varying elasticity*, which would destroy its uniformity (b) or *varying density*, which would make it cease to be incompressible, (c) or both, in which case both the difficulties would remain. (7) It was also found that light travels through transparent bodies. So the medium of its propagation must penetrate through such bodies. But if the æther freely pervaded such bodies, then there was no satisfactory explanation why light should have *different velocities* in different bodies. But actually it has. (8) Further, if light is a mere vibration of the æther and the æther penetrates through all bodies and pervades them, there was no reason why most bodies should be *opaque* to light. (9) If the æther were a solid medium, particularly if incompressible, even though elastic, then bodies moving through it ought to experience some resistance, but *no resistance* can be noticed. (10) Again, either the æther inside a body is *affected* by the matter contained in it, or it is not. (a) If it is not, then all bodies ought to be transparent to light as it is a vibration of the æther and not of matter. (b) If it is, then the æther inside the body should be affected in one way only, and the velocities of light of all colours should be the same; but they are not so. (11) Now if the æther were a vast store-house of energy, it might well have a spontaneous motion sometimes, but it has *no spontaneous* motion as a source of light is indispensable. (12) If the æther were an elastic solid, the vibration once produced might well continue, even after the source of light is shut out. But there are no such subsequent *oscillations*. (13) Various other hypotheses were put forward from time to time, *e.g.*, (a) the æther is like an *elastic jelly*, (b) or a *turbulent fluid*, (c) or that matter is like *vortices* or eddies in a stream. (14) None of the apparently contradictory properties of the æther explained *gravitation*. (15) The most insoluble problem, however, was the *æther-drag* or drift of æther. If a material body moves through the ocean of æther, does it carry with itself the æther contained in it, or does it allow the æther to pass through it freely, and so leaves it behind?

The Wave Theory did not remain without another rival. Michael Faraday (about 1833) had conceived of an electrified particle as an octopus-like structure, throwing out tentacles in the form of lines of force forming tubes of force. The tentacles from two such particles somehow took hold of one another and either pulled or pushed one another, causing the forces of attraction or repulsion. Clerk Maxwell (1831-79) developed the idea mathematically and regarded these lines of force as being formed out of electric and magnetic forces. In his hands the properties of the old æther became somewhat transformed, and his electromagnetic field of force had tubes of force having tension and lateral pressure due to electric strain and stress. He regarded the æther around an electrified body as being charged with energy so as to be in a sense polarised. He showed that light was an electromagnetic phenomenon caused by some unknown periodic disturbance in the æther. His remarkable discovery was that the velocity of light was equal to the ratio of any electrical quantity measured in Electromagnetic and Electrostatic units respectively. He laid down a new Electromagnetic Theory of Light. But he could not dispense with the æther, though he gave different properties to it, and his theory also was in essence a Wave Theory. But the classical Wave Theory of light was put to severe experimental tests, and it failed because two different experiments gave exactly opposite results.

Owing to the motion of the earth relatively to a luminous heavenly body, a change called "*aberration*" must occur in the direction in which the waves of light from that body appear to travel, when viewed by an observer on the earth. As the earth revolves round the sun, the direction in which a star is seen would be different in different seasons. The stars appear to describe small orbits around their true positions, as a result of the orbital motion of the earth compounded with the velocity of light. But the velocity of light would differ according to the medium through which it passes, and would be reduced if a telescope were filled with water instead of air. In 1871 Airy and Hoek proved by experiment that the aberration of the fixed stars is the same whether the telescope is filled with water or with air. This result could be accounted for mathematically by the assumption that æther waves were *partly* carried along by the moving matter with a velocity reduced in the ratio $(1-\frac{1}{\mu^2})$ where μ is the refractive index; or else the angle of aberration would not be independent of the substance with which the telescope is filled.

On the other hand, in 1887, Michelson and Morley carried out an experiment to test the relative motion of the earth and the æther. If there were any relative motion, then the time taken by a ray of light to pass to and fro along a given distance parallel to the earth's motion would not be the same as that taken by a similar ray travelling over the same distance but perpendicular to

the earth's orbit. These rays can, therefore, be made to have different phases and would cause interference. But not the slightest sign of any displacement of the interference fringes was observable when the apparatus was rotated through an angle of 90°. The only possible conclusion was that the velocity of light is not in the least affected by the motion of the earth, and that therefore the æther in the neighbourhood of the earth did not remain at rest in space but was *wholly* carried along by the earth. Subsequent experiments also, including that of Trouton and Noble, have generally confirmed the same result. (Prof. Jauncey's *Modern Physics*, p. 446.)

In 1893-95 Fitzgerald and Lorentz put forward a hypothesis that the length of the measuring rod itself is altered with the motion of the rod, and that a rod held West to East in the direction of the motion of the earth contracts, and is smaller in length than if the same rod were held North to South at right angles to that motion. However startling the theory of the shortening of the measuring rod may appear, there was no other apparent explanation of the contradictory results obtained by the above experiments.

There was yet another experimental result which destroyed the old Wave Theory of light. The chief characteristic of a wave propagation is its continuity. Theoretically the energy of a radiation for a given temperature should be proportional to the inverse fourth power of the wave length. So with a decrease in the wave length λ the energy increases still more rapidly. This equation would give a continuously rising curve. Experimentally, cavity radiation, *i.e.*, black body radiation, which is a perfect kind of radiation as it has all colours, depends on the temperature of the body only and is independent of the material of the cavity. When the cavity radiation, passed through a prism was observed by means of a bolometer, it was found that as wave length decreased, the energy rose up to a maximum, and then fell again with further decrease. It was noticed that the greater the temperature, the more the maximum shifted towards the violet side. Thus the hotter the source, the nearer to the violet side is the concentration, *i.e.*, more violet rays are emerging. The wave length corresponding to the maximum of the curve was represented by Wien's law λ_m T=constant, where λ is the wave length for the maximum energy and T is the temperature. The old Wave Theory utterly failed to account for the occurrence of the maximum at an intermediate position, which could not occur in a continuously rising curve.

The result that followed is the well-known "violet catastrophy" showing almost an infinite energy for λ approaching zero. In the words of Sir James Jeans [*The Mysterious Universe*, p. 32]:

"If light consisted of waves like the waves of the sea, it can be shown that all the light of the analysed sunlight ought to be found at the extreme violet end of the spectrum. Not only so, but extreme violet light waves have an

unlimited capacity for absorbing energy, and as they have their mouths permanently wide open, all the energy of the Universe would rapidly pass into the form of violet or ultra violet radiation travelling through space."

With all these results it might well have been expected that at the end of the nineteenth century, there would be an abandonment of the Wave Theory; but as a particle theory was considered to be an impossible theory there was no help.

In 1900 Professor Planck announced his famous Quantum Theory. According to him the processes of Nature are by jumps or jerks in indivisible quantities. He regarded the process of light absorption as discontinuous For each wave length there is a definite associated quantity of energy. $E_v = hv$ is the fundamental equation in which h is a universal constant. This means that the size of a unit of energy depends on its frequency; for each frequency there is a distinct unit; and the greater the frequency the greater the energy. This assumption explained the occurrence as well as the shifting to the violet side of the maximum limit of energy with temperature. In 1905 Professor Einstein extended the idea to radiation as well. On this extended theory, a beam of light consists of discreet units, light quanta or photons. Light is propagated in unbroken photons, a fraction of a photon not being seen. Energy is always a complete photon or a multiple of photon, but not a fraction. Now one would have imagined that the conception that energy moves in indivisible quanta would have at once pointed the way to a particle theory. But simply because energy was measured in terms of frequency, and frequency was believed to be incompatible with any particle theory, the tenacious adherence to the Wave Theory continued, but it was coupled with a hypothesis of sudden jumps which would make it almost a particle theory.

The *Photo-electric effect* was another blow to the Wave Theory. If light of a definite frequency be thrown on a metal plate, electrons coming out of it have a sharp maximum velocity. It is found experimentally that (1) the velocity of such electrons is independent of the intensity of the falling light, while (2) the rate of the emission of electrons is proportional to intensity. This means that the velocity does not depend on the intensity at all, but depends on frequency only; the greater the frequency of the incident light, the greater the velocity of the emerging electrons. After this experimental result the Wave Theory again failed, because according to it the intensity ought to have controlled the velocity. But Prof. Einstein's explanation based on Planck's Quantum Theory came to the rescue. If light fell on the plate in quanta, and only one quantum was absorbed by an electron, then its velocity would be the same, so long as light of the same frequency was falling. The increase in intensity would merely increase the number of the electrons that are liberated, and not their velocity. It was assumed that out of the quantum of energy

absorbed, part was utilized in liberating the electron and the remainder gave to it kinetic energy. This explanation also in reality confirmed that light consisted of indivisible particles, as discontinuity is inconceivable in waves.

In 1905 Prof. Einstein first announced his epoch-making Theory of Relativity; the general theory was completed later in 1915-17. It was intended to explain the result obtained by Michelson and Morley, and is based on the assumption that the velocity of light is an absolute constant. Not only is it the utmost maximum possible, but the velocity of light measured by an observer on any moving body relative to himself is always the velocity of light itself, *i.e.*, light seems to him to take the same time to overtake him whether he is moving or is at rest. However fast the observer may be moving, his own velocity as compared to the velocity of light is always zero. As Prof. Jauncey (*loc. cit.*, p. 448) has put it, an observer on the earth, when measuring the velocity of light would find it the same as another observer on a planet moving with a speed half that of light relative to the earth. This is so, although the velocity of light is perfectly definite, *viz.*, $3 \cdot 10^{10}$ cm. per sec. So far this assumption has worked tolerably well within the Solar System. The theory of Relativity, as propounded by Prof. Einstein and Prof. Minkowski, does not directly touch the conception of light. It would, therefore, be quite out of place to discuss here whether a new interpretation of Relativity based on a different hypothesis is not theoretically possible.

Relativity has no doubt altogether changed the conception of æther. Scientists now avoid that word, and prefer to call it space endowed with certain properties. Some scientists go so far as to regard it merely as a frame of reference, and according to Sir James Jeans (*Mysterious Universe*, pp. 92-93) "it is a creation of thought, not of solid substance"—"a pure abstraction". Prof. C. G. Darwin (*New Conceptions of Matter*, pp. 23-24) considers that the æther has not been completely abolished, but is merely space endowed, among others, with the property of undulation—"it is a true universal carrier", and its business is to carry by its undulations energy placed in its charge. Sir A. S. Eddington (*The Nature of the Physical World*, p. 31) holds that although motion with respect to the universal ocean of æther eludes us and 'velocity through æther' is meaningless, "this does not mean that the æther is abolished. We need an æther. The physical world is not to be analysed into isolated particles of matter or electricity with featureless interspace. We have to attribute as much character to the interspace as to the particles, and in present day physics quite an army of symbols is required to describe what is going on in the interspace . . . The æther itself is as much to the fore as ever it was, in our present scheme of the world". Now if the interspace is not a mere void or vacuum, but possesses certain characters, the æther exists,

though we may give to it new properties which our new theories may now require. Indeed, if light is a mere wave motion, there being nothing material which is translated forward from point to point, then unless the whole thing is illusory, there must be some medium which vibrates or else the waves would not be carried along. It is immaterial whether we like to call it æther or space endowed with the property of undulation.

The discovery of the electron by Sir J. J. Thomson during the close of the last century followed by the announcement of the atomic system made by Lord Rutherford in 1911, that it consisted of electrons revolving round a nucleus concentrated as a tiny speck, might well have led on to such a hypothesis of light as one can picture in one's mind. But Professor Niels Bohr's electronic orbits, of definite sizes and shapes, without any intermediate orbits, and representing different levels of energy, put forward in 1913, helped to give to light a mere intangible character. Light was now nothing substantial, but a mere non-material energy, representing the difference of two levels of energy in the electronic orbits. Electrons go whirling round in definite orbits, and every now and then, quite spontaneously, jump suddenly from one orbit to another; this change of orbit implies a difference in levels of energy and this difference is represented by light. As Dr. Whitehead (*Science and the Modern World*, p. 164) has put it:

"The difficulty with the quantum theory is that, on this hypothesis, we have to picture the atom as providing a limited number of definite grooves, which are the sole tracks along which vibration can take place...".

One should have again imagined that the assumption of separate and distinct orbits, without any continuity would have been sufficient to demolish the Wave Theory. But this was still not to be.

Professor Einstein in 1917 carried the hypothesis still further right up to its logical conclusion. Planck's Quantum theory must destroy the Law of Causation itself. Now there was no such thing as cause and effect. There was an apparent capriciousness in Nature. It acted somewhat arbitrarily. One could not predict with certainty which of a number of possible states would follow a particular state. The whole thing was a mere matter of chance or probability, not certainty. The uncertainty is not due to our ignorance, but is natural and inherent. There is an increasing "randomness". On investigating the statistics of the jumps, Professor Einstein found that all could not be caused by heat or radiation, and that some of the jumps must necessarily be altogether spontaneous. Here was another opportunity for abandoning the Wave Theory, and not the Law of Causation. But the theory was too firmly planted in scientists' minds to be so easily dislodged. Still more startling experimental results confirming the particle theory were to follow before it could even be modified.

Experiments had established that (1) an α particle (which is the nucleus of a helium atom) can collide with a hydrogen nucleus, and the two dart off in

different directions. (2) Similarly an α particle colliding with a helium nucleus has been photographed, and (3) electrons are found to be scattered by atoms. But α and β particles and electrons were then still supposed to be mere particles. In 1923 Professor Compton discovered that X-rays when falling on electrons behave exactly like a swarm of particles, and are scattered as if material particles, moving as separate detached units, collide with electrons and are deflected like billiard balls. The calculation of energy of the photons after the hits verified not only the conservation of energy but also the conservation of momentum. Professor Compton found that the wave length of the scattered photon was lengthened after its collision with an electron, varying with the angle of scattering. The track of an electron, in recoiling from an X-ray, was photographed by means of the cloud produced in a chamber filled with water vapour. If all the conditions of energy and momentum, required by the Law of Dynamics, are satisfied by a photon, one wonders what more is required to prove that light is not a mere wave.

Reference has already been made to the photo-electric effect. The collision of a photon not only with an atom, but also with a molecule, has been established. If the photon of very short wave length, like X-rays, strikes an atom, then the force exerted on the outer electron being comparatively very great, the electron is knocked out and photo-electric effect is produced. On the other hand, those of longer wave lengths do not produce effect to the same extent. In 1928 Sir C. V. Raman observed the scattered light from a mercury arc when passed through a liquid, and found light not only of the same frequency but also of both higher and lower frequencies giving extra lines in the spectrum. Differences in frequencies between such extra lines and the original line corresponded to the frequency of the scattering molecules of the liquid. The result showed that the molecules absorbed just those quanta which had their own frequency, and let through the rest; and further that the effect of the collision of photons with the molecules was either (1) that the photon imparted some of its energy to the molecule, so that the scattered ray was of lower frequency or (2) that the molecule gave a part of its energy to the photon, so that the emerging photon had a higher frequency. This also showed that light behaved as separate units.

As the particle nature is now being denied even to an electron, it is convenient to mention at least one experimental result showing that electrons behave like a swarm of particles. This is *Scintillation*. A scintillating screen is made by lightly powdering a sheet of glass with zinc sulphide crystals. This substance has the property that if one of its crystals is struck by an electron, it gives out a spark, which however is so faint that it can be seen only in a dark room with the help of a magnifying lens. When the prepared screen is exposed to a stream of electrons, scintillations appear irregularly all over it. The behaviour is like that of shower of rain falling on the screen,

each scintillation being caused by a separate drop. The irregular scintillations *prima facie* disprove that there is any wave impinging on the screen.

All the above-mentioned experimental results unmistakably pointed to a particle structure of light and matter. But prejudice in favour of the Wave Theory was over a century old and still remained unshaken. But on any wave theory, waves must of a necessity go on constantly spreading indefinitely. Existence of fossils, which have lain buried in rocks for hundreds of millions of years, becomes utterly inexplicable. By this time they should have evaporated away in waves. But contrary to this classical conception of dispersing more and more, the fundamental fact of regathering of light into h-units stares us in the face. Attempts have been made to explain the contradiction by what are characterised as the "Collection-box" theory and "Sweepstake" theory. The first would correctly represent fractions of waves entering an atom in succession, but is admittedly untenable. The second is nothing more than the mere law of chance. Both have had to be used indiscriminately. The hesitating indecision to give exclusive preference either to the classical laws or the quantum laws has been described in an expressive way by Sir William Bragg, who has remarked that "we use the classical theory on Mondays, Wednesdays and Fridays, and the quantum theory on Tuesdays, Thursdays, and Saturdays." Sir A. S. Eddington has felt compelled to feel a little sympathy towards the man whose philosophy of the Universe takes one form on week-days and another form on Sundays. The fact is that in this state of uncertainty both the classical laws and quantum laws, though radically irreconcilable, are applied together. In the words of Sir A. S. Eddington, "the whole procedure is glaringly contradictory but conspicuously successful" (*loc. cit.*, p. 194). Prof. Bridgman's "Operational Viewpoint" now lays down that a concept is utterly meaningless, unless we at the same time describe the operation by which it is measured. It is merely the sum total of the operations used to measure it, and varies with the set of operations. (Jauncey, *loc. cit.*, pp. 534-39).

It must, however, be admitted that there were the two phenomena of interference and diffraction which remained outstanding and apparently proved the Wave Theory of light and made the old Corpuscular Theory an impossible one. Without doubt light can interfere and is also diffracted. The old theory cannot explain how it can do either; but the Wave Theory satisfactorily explains both.

Now although light was regarded as a mere wave motion, protons, electrons, atoms and molecules were considered as definite particles whose motions and positions could be pictured. But electrons were found to be diffracted, and also protons were found to be capable of being diffracted. It was discovered by Messrs. Davisson and Germer that electrons are systematically scattered from a sheet of nickel into certain definite directions, showing the peculiarity that would be due to the diffraction of X-rays by the crystals of

nickel. The closely-packed atoms of a solid body form a pattern and serve the purpose of a diffraction grating. Prof. G. P. Thompson applying the principle of "powder photograph" let a very narrow and straight pencil of electrons moving at a very high speed, fall on an extremely thin metallic film, so thin as to be nearly transparent, and then on to a photographic plate placed beyond the film. The image that was produced consisted of a central spot with circular rings round it, due to the diffraction of the electrons by the small crystals of the metallic film. Recently the diffraction of whole atoms has also been observed. It is not too much to predict that even molecules will soon be diffracted.

Now the position became irreconcilable. Some experiments definitely showed that photons, protons, electrons, and atoms behaved like solid particles, while others indicated that they behaved like waves. They behaved sometimes as particles and sometimes as waves, and there was no general principle yet known which could tell how they would behave. There was some sort of an apparent duality, so that photons, protons, electrons and atoms appeared to be both particles and waves. There remained only two possible courses open. It was like the horns of a dilemma :—

(A) Either not only atoms, electrons and protons, but also light should be regarded as particles and distinct individualities assigned to them. (B) Or one should not only deny individuality to light, but also deny it to protons, electrons and even atoms, and ultimately to molecules also. The conviction against the Corpuscular Theory was so firmly fixed that the choice was made per force of the second alternative.

In 1925 Prof. Heisenberg laid down the foundation of the New Quantum Mechanics or Matrix Mechanics, an entirely mathematical theory, adopting an algebraic method and using matrices, an advanced form of determinants. Prof. De Broglie introduced the idea of waves, though in a rather vague and general way. In 1926 Prof. Schrödinger developed the theory mathematically and applied the method of Differential Equations. In 1928 Prof. Dirac combined Relativity with Quantum Mechanics and laid down Equations known after his name. We have now a perfect system of Wave Mechanics so far as the mathematical aspects are concerned; but it has not even the faintest resemblance to a physical theory.

How the new theory explained interference, the principal cause of the trouble, which according to Prof. Dirac also cannot be explained on any particle theory at all, may be stated in his own words (*Wave Mechanics*, p. 15):

"The answer that quantum mechanics gives to the difficulty (of interference caused by a beam of light when split up into two components of equal intensity) is that one should consider each photon to go partly, into each of the two components, in the way allowed by the idea of the superposition of states. Each photon then interferes only with itself. Interference between two different photons can never occur."

In 1927 Prof. Heisenberg propounded a new Uncertainty Principle or Principle of Indeterminacy that it is wholly uncertain how an electron, for example, will behave. An electron is now supposed to be a train of waves stretching from infinity to infinity; the electron can be assumed to be anywhere in this train, only its speed is known, but its position is unknown. But once any one tries to observe it, the infinite train instantaneously contracts to a zero point, the position becomes known, but the speed becomes indeterminate. A wave group or wave train may have any size or shape; but the position is when known, the speed is indeterminate. A wave group or train must always be moving, it cannot be stationary, its shape also is constantly changing, the number of crests is also changing, generally speaking the number goes on increasing as time passes; the spreading is very rapid if the length of the region is very short, but it is slow in a long train. The train of waves representing an electron goes on spreading from infinity at one end to infinity at the other. But the moment the electron is attempted to be observed, its whole infinite train contract immediately to a zero point. It is supposed to be impossible to know with precision both the velocity and the position at one and the same time.

For an illustration, we may take one of the nearest stars like Sirius, which is fifty-one million million miles away, and from where light travelling at the rate of 186,000 miles per second takes over $8\frac{1}{2}$ years to reach the earth. A quantum of light that starts from it in the form of waves will have spread out almost to immeasurable dimensions by the time it reaches the earth. So long as it has hit nothing, it has gone on expanding continually to an immense extent. But as only a whole quantum, and not any fraction of it, can enter an atom at a time, the result must be that as soon as that quantum in the form of an infinite wave hits an atom on the earth, the infinite train must instantaneously re-gather itself, and contract to almost a zero point; and in this way just one quantum of it enters the atom. The only feasible hypothesis put forward, which is more of an excuse than an explanation, is that only one aspect can be seen in one experiment at a time, and that no experiment has been or can be designed which will show both the particle and the wave aspects at one and the same time.

Prof. C. G. Darwin (pp. 79-80) has suggested an experiment in which a stream of electrons is sent out through two very small holes close together, and then scintillations looked for, which would most probably appear as isolated sparks, but the sparks would all occur in certain bands, and none at all where diffraction theory predicts darkness; but if one hole were stopped, the interference would be destroyed and there would be scintillations everywhere. I submit that in this way both interference bands and scintillation can be seen simultaneously on the same screen. These effects would be easily intelligible on a new particle theory, if light particles emerge

from electrons at fixed intervals corresponding to the periods of their rotations.

According to Sir James Jeans, as radiation, electrons and protons "can appear now as waves and now as particles", they "appear to be particles and waves *at the same time*". He adds, "Clearly we can only preserve our belief in the uniformity of nature by making the supposition that particles and waves are in essence the same thing". (p. 35) At another place (pp. 68-69) he says,. "Possibly we may come fairly to the truth if we think of matter and radiation as two kinds of waves—a kind which goes round and round in circles, and a kind which travels in straight lines. This may express the whole difference between matter and radiation, matter being nothing but a sort of congealed radiation travelling at less than its normal speed . . These waves are of two kinds, bottled up waves, which we call matter, and unbottled waves, which we call radiation or light . . . These concepts reduce the whole universe to a world of radiation, potential or existent". "Matter and radiation are found equally to resolve themselves into waves . . . We live in a universe of waves, and nothing but waves."

But just to show what is meant by these waves, I may quote from Sir James Jean's latest book (*The New Background of Science*, pp. 241-42):

"We treat the waves as wave of probability, their extension in space defining the uncertainties of our knowledge. The waves are no longer waves of energy, but of the chance of finding energy . . . So, in the last resort, the waves which we describe as light waves, and those other waves which we interpret as the waves of an electron and a proton, also consist of *knowledge*—Knowledge about photons, electrons and protons respectively."

So unfortunately even these waves are not real waves at all, but purely imaginary and fictitious waves—mere waves of probability. These waves are not now even waves of energy, but only of chance, and so cannot be located in space and time, but are a mere something unthinkable expressed by mathematical equations only. This is the only way in which absurdities like the instantaneous regathering of light is tried to be explained. The waves are a mere mathematical fiction.

Prof. Heisenberg took up the idea that a wave motion can be expressed by means of an infinite Fourier's series, and by suitably selecting the co-efficients any kind of waves can be represented by a process of superposition. In this way a curve would be characterised only by a set of co-efficients in a given order With a view to secure some stability for an atom and to maintain Prof. Bohr's idea of sudden jumps from orbit to orbit, he used square matrices, an advanced form of determinants, to represent the wave motion. Prof. Einstein's and Prof. Minkowski's continuum had only four dimensions, three of space and one of time. But the Wave Mechanics requires a system of waves of seven dimensions to explain the behaviours of two

electrons, of ten dimensions to explain the behaviours of three electrons, and so on, in fact one plus three times as many dimensions as there may be electrons. The result of this mathematical manipulation is bound to be excellent, because the equations have been deliberately invented by a great mathematical mind to fulfil certain desired conditions; but it involves an abandonment of the commutative laws of multiplication. We had for long supposed that p multiplied by q is equal to q multiplied by p. But now the fundamental equation is that $p \times q - q \times p = \frac{h}{2\pi}\sqrt{-1}$ where h is the Planck's constant. Of course in such an equation p and q cannot be the ordinary arithmetical numbers; they are sets of numbers in certain orders. Sir A. S. Eddington on p. 207 remarks, "All authorities seem to be agreed that at, or nearly at the root of everything in the physical world lies this mystic formula. We do not yet understand that; probably if we could understand it, we should not think it so fundamental."

This basic formula for the modern conception of a light wave is interpreted differently by Prof Born, Prof. Dirac and Prof. Schrödinger. According to Sir A. S. Eddington,: "Schrödinger's theory is now enjoying the full tide of popularity, partly because of intrinsic merit, but also, I suspect, partly because it is the one of the three that is simple enough to be misunderstood... I do not see the least likelihood that his ideas will survive long in their present form". (pp. 210-11).

Prof. Schrödinger imagines something still more unreal than the æther, *viz.*, a sub-æther as a seat of some sort of oscillations, with beats; but "these beats are not themselves to be identified with light waves, they are in the sub-æther, whereas light waves are in the æther. The beats merely provide the oscillating source which in some way not yet traced sends out light waves of its own period." Sir A. S. Eddington's comment on this conception is "Schrödinger's wave-mechanics is not a physical theory but a dodge—and a very good dodge too. The fact is that the almost universal applicability of this wave-mechanics spoils all chance of our taking it seriously as a physical theory." (p. 219).

Prof. C. G. Darwin's opinion is that "the present theory of the interaction of light with matter is really rather unsatisfactory. The theory, in its final form due to Heisenberg and Pauli, is most extremely difficult; indeed it has been only in the hands of a few of the leading workers in this field that anything has been made of it, and it is, I think, rather widely felt that it is not founded on the right lines." (p. 159).

It is doubtful whether Sir J. J. Thomson really believes in the supposed waves of probability. His latest exposition is a hypothesis of granules moving with tremendous velocity and having a mass almost infinitesimal in comparison with an electron, their resultant attraction or

repulsion being due to the difference in the sense of rotation of vortex filaments.

Now once imaginary quantities like $\sqrt{-1}$ enter into the wave equation, we step out of the real world into an unreal world, and begin to express things by weird mathematical formulæ which can neither be pictured nor visualised. Physics then becomes a close preserve of the mathematicians, who deal with nothing but mathematical symbols, not capable of any intelligible physical interpretation. Solid matter disappears into something insubstantial, the tangible changes into the intangible, and the real into the imaginary. To quote Sir James Jeans again, "The essential fact is simply that all the pictures which science now draws of nature, and which alone seem capable of according with observational fact, are mathematical pictures. Most scientists would agree they are nothing more than pictures—fictions if you like, if by fiction you mean that science is not yet in contact with ultimate reality; . . . . . it is the general recognition that we are not yet in contact with ultimate reality." (p. 111).

It has also been remarked that "the Universe appears to have been designed by a pure mathematician" that "the final truth about a phenomenon resides in the mathematical description of it" and that what we know as light merely "exists in a mathematical formula; this, and nothing else, expresses the ultimate reality." As Dr. Whitehead (p. 143) has put it "Scientific thought is outrunning common sense." The consequences of the assumption that everything in this universe is a mere mathematical equation of an imaginary wave would make the concept a mere structure of pure thought incapable of realisation in any sense which can properly be described as material. In the words of Sir James Jeans, "The universe cannot admit of material representation, and the reason, I think, is that it has become a mere mental concept." "To-day there is a wide measure of agreement, which on the physical side of science approaches almost to unanimity, that the stream of knowledge is heading towards a non-mechanical reality; the universe begins to look more like a great thought than like a great machine. The old dualism of mind and matter . . . seems likely to disappear . . . through substantial matter resolving itself into a creation and manifestation of mind." (p. 137).

The situation cannot be summed up better than in the words of Sir A. S. Eddington, "Nowadays when enthusiasts meet together to discuss theoretical physics the talk sooner or later turns in a certain direction. You leave them conversing on their special problems or the latest discoveries; but return after an hour and it is any odds that they will have reached an all-engrossing topic—the desperate state of their ignorance. This is not a pose. It is not even scientific modesty, because the attitude is often one of native surprise that Nature should have hidden her fundamental secret successfully from such powerful intellects as ours. It is simply that we have turned a corner in the path of

progress and our ignorance stands revealed before us, appalling and insistent. There is something radically wrong with the present fundamental conceptions of physics and we do not see how to set it right." (p. 179).

So this is where the scientists have arrived! And why? Might it not be that over a hundred years ago the initial mistake was made and ever since that time it has been taken for granted that a particle theory of light is an impossible theory, and that, therefore, there is no option but to have a wave theory, howsoever imaginary the waves may be? Might it not possibly be that the rival theories were like the parting of ways, and the choice of the wrong path has led us into an arid desert, into which we have been lured because of the openness of space untrammelled by any obstacles, in preference to the dense and dark forest which had deterred us, but beyond which, if we had pierced through it, lay the beautiful vistas of rich gardens? Might it not be that the greater the progress we are now making at every step towards the imaginary goal, the more we are being drifted away from reality? The imaginary world in which, out of our own choice, we have landed ourselves bristles with greater anomalies than what were sought to be avoided, and is full of apparent absurdities. The present-day physicist's mind is hankering after something real—a new dynamical world, the equations to express which would not involve imaginary factors so as to make it entirely illusory. Mere mathematical formulæ, howsoever perfectly well they may work on paper, cannot satisfy the philosophic mind unless they evolve something comprehensible.

In this desperate state of affairs, a sceptic may be excused if he begins to doubt the very axioms on which the modern conceptions are based: Was Newton right when he conceived that a material body will continue to move for all time to come with the same constant velocity in a straight line so long as it is not disturbed by any force? Was Huygens correct in his belief that in the propagation of light nothing material travels from one point to another but, that there is an imaginary medium which merely vibrates? Were not physicists wrong when they considered an æther indispensable, which all at the same time was solid, elastic, torsionally rigid, incompressible or contractile, uniform in all directions and yet polarised, varying in density, wholly carried along by moving matter when æther is just outside it, but only partially carried along when contained inside the matter? Are we bound to assume that electrons and protons are the ultimate fundamental units of Nature, and that there are no smaller worlds within them? Did Professor Planck propound the truth when he stated that there was a certain arbitrariness in Nature, and that a wave motion can be discontinuous? Must we concur in Professor Einstein's assertion that the Law of Causation does not exist? Is he right in saying that the velocity of light relative to a moving observer is always the same, no matter how fast he is moving? Are we really to believe

that there is no such thing as force, that there is nothing else in the Universe except relative motion, and that space has higher dimensions, has properties other than mere voidness and is in itself curved? Should we necessarily accept Professor Heisenberg's Principle of Uncertainty and Indeterminacy? Are we compelled to believe with Professors Schrödinger and Dirac that this world is comprised of nothing but mere waves of probability? Is it really the case that the only possible way of understanding physical phenomena is by starting with a unit of time as $\sqrt{-1}$, and by abandoning the laws of multiplication? Have we now no option left but to regard the whole universe as a mere mental concept, and everything around us as nothing but a creation of the mind?

One feels an irresistible temptation to answer these questions by saying that the remarkable degree of perfection attained by the mathematical theories has been at the sacrifice of all philosophical thought, and that the wonderful accuracy of experimental results has been completely at the expense of simplicity. No doubt a steam roller can most perfectly crush a flea but is it worth while employing such a heavy machinery for the purpose, if the same object can be attained by a much simpler process? Any method of reasoning which reduces the universe into something imaginary cannot furnish a satisfactory explanation of it. Man's instinct, I should think, would rebel against the notion that he is nothing but a system of imaginary waves, and is not a real entity.

Further researches alone will decide whether something simpler and more easy of comprehension cannot be had. As a way out of this impasse, last year, in all humility, I ventured to publish the details of a Rotational Theory of light as a part of a still more general theory, which may surmount the existing anomalies, explain all the known physical phenomena, and bring us back once again into the world of reality. Briefly speaking, that hypothesis is that light consists of material particles (called by me *radions*) which can emerge out of electrons only when their velocity is reduced to a limiting value C. These possess a wave motion in this way that besides their common longitudinal velocity C, and spins round their own axis, they also have different rotational motions corresponding to the revolutions of the electrons in their orbits from which they emerge. The forward motion is measured by the well known velocity of light, and the rotational motions by the periods of time during which they complete one revolution round the axis of their path. Their spin is at present not noticeable. The combined motion is a mere superposition of the three motions. The actual path of a radion is along a helix, a uniform curve round an ellipsoidal cylinder. The motion of a particle in a wave fashion shows both the particle and the wave aspects simultaneously, and reconciles the apparently contradictory experimental results. The formula $\lambda = C. t$ gives us all the results we want. Intensity is measured by the number of

radions per unit area in a cross-section and moving along the path. Reflection is easily explained by the impinging of radions on the atomic systems in a surface, and refraction by their piercing through the inter-spaces. The reflected beam will contain more of the light polarised in a plane parallel to the surface, and the refracted beam more of the light polarised in a plane perpendicular to it. Radions of one definite period will constitute a monochromatic light, in which exactly similar states will recur at intervals of time separated by the period, with the same maxima and minima in between. Permanent differences in phases will cause both interference and diffraction. For such effects, only a periodic motion is required, and nothing more. Molecules, atoms, electrons, protons and radions can all be diffracted. The rotational motions produce transverse vibrations explaining polarisation and double refraction. Radions rotating in planes almost parallel to the grains of a crystal are let through, while those perpendicular to it are stopped. Differences in colour are the result of the different rotational velocities. Decrease of velocity in denser media in which atoms are more closely packed is obvious. So is also pressure of light. Zeeman and Stark effects are explained by the effect of the field on the orbits of rotation, and Compton and Raman effects by the collision of radions with electrons, atoms or molecules. Similar rotational motions of electrons and protons can explain electrification, both negative and positive, and also explain an electric current, and that of emerging radions will explain electromagnetic induction. Electrons and protons will become particles of the same nature, the difference between them being merely rotational velocities, above and below a mean value. The supposed oscillations of electrons and protons are but angular rotations with circumferential velocity respectively less and greater than that of light. The rotational motions of molecules parallel to a fixed direction will explain magnetisation. Further, the constant angular momentum of a radion would explain the un-understood, mysterious "*h*". The constancy of "*h*" is a simple mathematical result of the rotation round an axis, which acts as a virtual central force. It crops up in every experiment because our measuring instrument is light And what is more, Nature need no longer be capricious or proceed by jumps. The sudden jumps from orbit to orbit are a necessary result of successive losses of mass due to the discharge of radions, which must be in multiples of one radion. The interval of time between successive emissions of radions from one atom in one tangential direction corresponds to the period of the revolution of the electron in its orbit. The difference in the losses of momenta caused by emissions on the inner and outer sides of two bodies will explain gravitation. With the restoration of the principle of Continuity, the objective Uncertainty will be removed and the Law of Causation re-enthroned !

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Sir James Jeans (p. 69) has suggested that "radiation may ultimately prove to be merely matter moving with the speed of light, and matter to be

radiation moving with a speed less than that of light. *But science is a long way from this as yet.*" I may be pardoned for being audacious enough to assert that that stage is within the reach of Science to-day.

On the occasion of Newton's last centenary, Prof. Einstein expressed the wish—"May the spirit of Newton's method give us power to restore unison between physical reality and the profoundest characteristic of Newton's teaching—strict causality." May I respectfully say that Omar Khayyam's philosophy holds good to-day, just as it did ever before :—

> " Yea, the first Morning of Creation wrote
> What the Last Dawn of Reckoning shall read."

VOTE OF THANKS BY PROF N. R. DHAR

I have great pleasure in proposing a hearty vote of thanks to Sir Shah Mohammad Sulaiman. It is an unique occasion for Indian science that an extremely busy Chief Justice of a big High Court is very keen on the advancement of science and learning. It is a matter of great gratification to us that we have been able to welcome Sir Shah Mohammad Sulaiman amongst us as a seeker of new knowledge. After an extremely brilliant career in the Universities of Allahabad and Cambridge in Mathematics, Sir Shah Mohammad Sulaiman went in for legal studies and pursuit of law in which he became a luminary in a short time, but he never forgot his alma mater and took an active part in the affairs of the Allahabad University for a number of years and we owe largely to him certain expansions in the science side of our university and the appointment of Dr. M. N. Saha, the Founder and first President of the Academy of Science, U. P.

I hope Sir Shah Mohammad Sulaiman's contribution to Mathematical Physics will be great credit to him as a man of science and a landmark in the development of Mathematical Physics in our country.

SECOND VOTE OF THANKS BY Dr. H. R. MEHRA

I have great pleasure in seconding the vote of thanks moved by my colleague Dr. N. R. Dhar. We are highly indebted to Sir Justice Sulaiman for presiding over the annual meeting of the Academy and his illuminating address. It is very kind of him to find time in the midst of his arduous duties as the Chief Justice of the High Court to come here and honour us by his presence. The U. P. Academy of Sciences, which is in a state of infancy, needs the fostering care not only of well-known scientists but also of eminent scholars and statesmen. I am sure that it will gain considerably from the words of encouragement and inspiration, which we have received from Sir Sulaiman to-day. In him we find a rare and unique combination of a scientist, scholar and administrator of laws and it is a great boon that we can depend upon him for help and advice whenever we need it. The U. P. Academy of Sciences stands for advancement in scientific knowledge, which will not only bring material prosperity to these Provinces, but it is also bound to alleviate the sufferings of mankind.

It is a great privilege to me to second the proposal for vote of thanks which I do most gladly.